EXPLANATION.

Due to the arrangement of the material, the binders found it impossible to place the plates of Wenzel, Gates and Wood anywhere except at the end of the volume. These plates are not named, only numbered. They come in three series.

Series 1, numbered consecutively Plate I (fig. 1) to Plate XI, (fig. 19) goes with Wenzel's paper.

Series 2, numbered 2 to 20, goes with Wood's paper.

Series 3, numbered V to XXI b, goes with Gates' article.

FOURTEENTH REPORT

OF

THE MICHIGAN ACADEMY OF SCIENCE

CONTAINING AN ACCOUNT OF THE ANNUAL MEETING

HELD AT

ANN ARBOR, MARCH 27, 28 AND 29, APRIL 20, 1912.

PREPARED UNDER THE DIRECTION OF THE COUNCIL

BY

RICHARD DE ZEEUW

SECRETARY

BY AUTHORITY

LANSING, MICHIGAN
WYNKOOP HALLENBECK CRAWFORD CO., STATE PRINTERS
1912

LETTER OF TRANSMITTAL.

To Hon. Chase S. Osborn, *Governor of the State of Michigan:*

Sir—I have the honor to submit herewith the Fourteenth Annual Report of the Michigan Academy of Science for publication, in accordance with Section 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,
RICHARD de ZEEUW,
Secretary.

East Lansing, Mich. ———, 1912.

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OFFICERS 1912-1913.

President, E. C. Case, Ann Arbor.

Secretary-Treasurer, Richard de Zeeuw, East Lansing.

Librarian, A. G. Ruthven, Ann Arbor.

VICE-PRESIDENTS.

Agriculture, Geogre J. Bouyoucos, East Lansing,
Geography and Geology, F. T. Carlton, Albion.
Zoology, Peter Okkelberg, Ann Arbor.
Sanitary and Medical Science, C. A. Behrens, Ann Arbor.
Botany, Ernst A. Bessey, East Lansing.
Economics, H. S. Smalley, Ann Arbor.

PAST-PRESIDENTS.

Dr. W. J. Beal, Amherst, Mass.
Professor W. H. Sherzer, Ypsilanti.
Bryant Walker, Esq., Detroit.
Professor V. M. Spaulding, Tucson, Ariz.
Dr. Henry B. Baker, Holland, Mich.
Professor Jacob Reighard, Ann Arbor.
Professor Chas. E. Barr, Albion.
Professor V. C. Vaughan, Ann Arbor.
Professor F. C. Newcombe, Ann Arbor.
Dr. A. C. Lane, Tufts College, Mass.
Professor W. B. Barrows, East Lansing.
Dr. J. B. Pollock, Ann Arbor.
Professor M. S. W. Jefferson, Ypsilanti.
Dr. Chas. E. Marshall, East Lansing.
Professor Frank Leverett, Ann Arbor.
Dr. F. G. Novy, Ann Arbor.
Professor Wm. E. Praeger, Kalamazoo.

COUNCIL.

The Council consists of the above-named officers and all Resident Past-Presidents.

MEMBERSHIP OF THE MICHIGAN ACADEMY OF SCIENCE, MAY, 1912.

(Charter members are marked with an asterisk.)

This list does not contain the names of those who have not paid any dues for two years or more. Failure to pay dues is taken as an indication that it is desired to have the membership lapse. See Chap. I. 3 of the By-laws of the Michigan Academy of Science.

RESIDENT MEMBERS.

A

Adams, H. C., Ann Arbor.
Alexander, S., 706 Seventeenth St., Detroit.
Allen, R. C., Lansing.
Allen, Ruth F., East Lansing.
Anderson, A. Crosby, East Lansing.
Andre, Ruba, 54 Webb Ave., Detroit.
Andrews, A. W., 186 Lathrop Ave., Detroit.
Arnos, Edw. M., Olivet.

B

Baker, H. B., Museum, Ann Arbor.
Baker, Howard B., 281 Warren Ave., W. Detroit.
*Barr, Chas. E., Albion.
*Barrows, Walter B., East Lansing.
Bean, Fred A., 659 Townsend Ave., Detroit.
Behrens, C. A., 620 Church St., Ann Arbor.
Bennett, C. W., 58 Hanchett St., Coldwater.
Bessey, Ernst A., East Lansing.
Bigelow, S. Lawrence, Ann Arbor.
Bissell, John Henry, 525 Bank Chambers, Detroit.
Blain, Alexander, 1105 Jefferson Ave. E., Detroit.
Bouyoucos, Geo. J., East Lansing.
Brenton, S., 121 Alexandrine Ave., Detroit.
Bricker, J. L., Saginaw, W. Side.
Brigham, E. M., Battle Creek.
Brotherton, Wilfred A., Rochester.
Brown, Chas. W., East Lansing.
Brown, Wm. H., Bur. of Science, Manila, P. I.
Burham, Ernst, 509 S. Rose St., Kalamazoo.
Burt, Frederick, East Lansing.
Butler, Jefferson, 1117 Ford Bldg., Detroit.

C

Campbell, Edward de Mille, 1555 Washtenaw Ave., Ann Arbor.
Carlton, Frank T., Albion.
Case, E. C., Ann Arbor.
Christian, E. A., Pontiac.
Clark, R. W., Ann Arbor.
Clark, L. T., c/c Parke Davis & C., Detroit.
Conover, L. Lenore, 114 Marston Court, Detroit.
Coons, G. H., East Lansing.
Cooley, Chas. H., Ann Arbor.
Cole, Harry N., 702 Forest Ave., Ann Arbor.
Collin, Rev. Henry P., 98 E. Chicago St., Coldwater.
Cook, Chas. W., Ann Arbor.
Cummins, Harold, 701 Trimble Ave., Kalamazoo.

D

Davies, Murig L., Bay City.
De Zeeuw, Richard, East Lansing.
Dietz, Ada K., 651 Champlain St., Detroit.
Dillon, Florence G., 432 Cadillac Ave., Detroit.
*Dodge, C. K., Port Huron.
Dunbar, Frances J., 610 So. Ingalls St., Ann Arbor.

E

Eustace, H. J., East Lansing.

F

*Farwell, Oliver A., 449 McClellan Ave., Detroit.
Ferry, Newell S., 430 Montclair Ave., Detroit.
Friday, David, Ann Arbor.
Frostic, F. W., St. Charles.

G

Gates, Frank C., 524 Elm St., Ann Arbor.
Gilchrist, Maude, East Lansing.
Giltner, Ward, East Lansing.
Glaser, O. C., Ann Arbor.
Gleason, H. A., Ann Arbor.
Goddard, Mary A., Ypsilanti.
Gurney, Chas. H., Hillsdale.

H

Hamilton, S. M., 1513 So. University Ave., Ann Arbor.
Hamilton, Walton H., Ann Arbor.
Harvey, Caroline C., 51 Winder St., Detroit.
Harvey, L. H., Kalamazoo.
Harvey, N. A., Ypsilanti.
Hedrick, Wilbur O., East Lansing.
Hegner, R. W., Ann Arbor.

Hill, C. L., 327 E. Huron St., Ann Arbor.
Hinsdale, W. B., Ann Arbor.
Hobbs, Wm. H., Ann Arbor.
Holm, M. L., Lansing.
Hore, R. E., Houghton.
Houghton, E. Mark, 130 Longfellow Ave., Detroit.
*Hubbard, Lucius L., Houghton.
Huber, G. Karl, 1330 Hill St., Ann Arbor.
Hunt, Walter F., Ann Arbor.
Hus, Henri, Ann Arbor.

J

Jeffery, J. A., East Lansing.
Jefferson, M. S. W., Ypsilanti.
Jones, Edward D., Ann Arbor.

K

Kauffman, C. H., Ann Arbor.
King, Mrs. Francis, Orchard House, Alma.
King, Francis, Alma.
Kleinstuck, Carl G., Saxonia Farm, Kalamazoo.
Koch, Catherine, Kalamazoo.
Kraus, E. H., Ann Arbor.

L

LaRue, Geo. R., Ann Arbor.
Leverett, Frank, Ann Arbor.
*Lombard, Warren P., 805 Oxford Road, Ann Arbor.
Lyons, A. B., 102 Alger Ave., Detroit.

M

McCain, Frederick E., 828 Ford Bldg., Detroit.
McCracken, Wm., Kalamazoo.
MacCurdy, Hansford, Alma.
McDaniel, Eugenia, East Lansing.
MacKay, Sarah D., Ann Arbor.
MacMillan, J. A., 666 Woodward Ave., Detroit.
McNall, Jessie, Hastings.
Magers, S. D., Ypsilanti.
*Manton, W. P., 32 Adams Ave. W., Detroit.
Marshall, Chas. E., East Lansing.
Martin, Helen M., 66 North Ave., Battle Creek.
Merrill, C. H., 349 Chene St., Detroit.
Miller, E. C. L., 66 Rosedale Court, Detroit.
Miller, Herbert A., Olivet.
Mitchell, James E., Alma.
Musselman, Harry, East Lansing.
Myers, Jesse J., East Lansing.

N

Nelson, Chas. D., South Haven.
*Newcombe, F. C., Ann Arbor.
Newcomb, Wm. W., 34 Mt. Vernon Ave., Detroit.
*Novy, Frederick G., Ann Arbor.

O

Obee, Chas. W., Adrian.
Okkelberg, Peter O., 1216 So. University Ave., Ann Arbor.

P

Parkins, A. E., Ypsilanti.
Parry, Carl E., Ann Arbor.
Patten, A. J., East Lansing.
Perkins, W. L., 228 So. Thayer St., Ann Arbor.
Pettee, Edith E., 83 Harper Ave., Detroit.
Pettit, R. H., East Lansing.
Phelps, Jessie, Ypsilanti.
Pieters, Adrian J., 506 E. Jefferson St., Ann Arbor.
Pollock, J. B., Ann Arbor.
Povah, Alfred H., 341 E. Jefferson St., Ann Arbor.
Praeger, Wm. E., 421 Douglas Ave., Kalamazoo.

R

Rahn, Otto, East Lansing.
Reeves, Cora D., Manistee.
*Reighard, Jacob, Ann Arbor.
Robinson, C. S., East Lansing.
Robison, Floyd W., Milan.
Roth, Filibert, Ann Arbor.
Ruthven, A. G., Ann Arbor.
Ryder, Edward H., East Lansing.

S

Scott, D. R., 1814 Wilmot St., Ann Arbor.
Scott, I. D., Ann Arbor.
Seaman, A. E., Houghton.
Shafer, Geo. D., East Lansing.
Shaw, Robert S., East Lansing.
*Sherzer, W. H., Ypsilanti.
Shull, A. F., 935 Greenwood Ave., Ann Arbor.
Smalley, H. S., Ann Arbor.
Smith, Richard A., Lansing.
Sperr, F. W., Houghton.
Spragg, F. A., East Lansing.
Sprague, R. F., Greenville.
Spurway, Chas. H., East Lansing.
Staley, Ethel M., 525 Walnut St., Ann Arbor.
*Stearns, Frances, 43 Terrace Ave., Grand Rapids.

Stewart, Walter W., 1345 Wilmot St., Ann Arbor.
*Strong, E. A., Ypsilanti.
Sutton, John M., 100 Englewood Ave., Detroit.
Swales, B. H., Grosse Isle.

T

Taverner, P. A., 55 Elmhurst Ave., Detroit.
Taylor, Fred M., Ann Arbor.
Taylor, Rose M., East Lansing.
Temple, C. E., Ann Arbor.
Thompson, Bertha E., East Lansing.
Thompson, Crystal, Ann Arbor.
Thompson, Elizabeth L., 520 E. Jefferson St., Ann Arbor.
Thompson, Helen B., Ann Arbor.
Turner, R. A., 8 West St., Hillsdale.

W

*Walker, Bryant, 205 Moffat Bldg., Detroit.
Wentworth, W. A., East Lansing.
Wenzel, Orrin J., 1926 Geddes Ave., Ann Arbor.
Wetmore, Mary, Allegan.
*Wheeler, E. S., 76 Delaware Ave., Detroit.
White, O. K., East Lansing.
Whitney, W. L., 108 Owen St., Saginaw.
Williams, C. B., 214 Stewart Ave., Kalamazoo.
Williams, G. S., Ann Arbor.
*Willson, Mortimer, Port Huron.
Wood, N. A., Ann Arbor.
Wood, L. H., Kalamazoo.

CORRESPONDING MEMBERS.

Barlow, Bronson, 207 Ninth St., S. W. Washington, D. C.
*Beal, Wm. J., Amherst, Mass.
Cooper, Wm. S., North Yakima, Wash.
*Davis, Chas. A., 1733 Columbia Road, Washington, D. C.
Edwards, S. F., Guelph, Ont., Canada.
Grose, Harlow D., 302 Osgood St., Joliet, Ill.
Holt, W. P., 1004 Jefferson Ave., Toledo, Ohio.
Jodidi, Samuel L., Ames, Iowa.
Kempster, Harry, Columbia, Missouri.
*Lane, Alfred C., Tufts College, Mass.
Lancashire, Mrs. J. H., Manchester, Mass.
Loew, F. A., Obee P. O., Huntington, Ind.
Nattress, Thomas, Amherstburg, Ontario.
Pearse, A. S., Madison, Wis.
Taylor, Frank B., Fort Wayne, Ind.
Thomas, Leo, Troy, Ohio.
Winter, Orrin B., Geneva, N. Y.
Wuist, Elizabeth, Fifth and Garfield Sts., Dayton, Ohio.

MINUTES OF THE EIGHTEENTH ANNUAL MEETING OF THE ACADEMY OF SCIENCE.

COUNCIL MEETING.

March 27, 1 P. M.

The meeting was called to order by the President.

Members present were: Praeger, Jefferson, Sherzer, Leverett, Taylor, Ruthven, Giltner, Newcombe and de Zeeuw.

An invitation from the American Philosophical Society at Philadelphia inviting the Academy to send a delegate was read by President Praeger. Professor Hobbs offered to represent the Academy, but, since he was also a member of the Philosophical Society, he thought it might be well to appoint someone else. Dr. Ruthven moved to have Dr. G. Carl Huber, at present resident in Philadelphia, represent the Academy. The motion was seconded and carried.

RICHARD DE ZEEUW,
Secretary.

GENERAL MEETING OF THE ACADEMY.

March 27, 2 P. M.

The meeting was called to order by President Praeger.

A motion was made to appoint a committee to audit the Treasurer's books. Seconded. Carried.

The Chair appointed Professor Leverett and Dr. Hus.

Professor Newcombe made a motion to adjourn. Seconded. Carried.

RICHARD DE ZEEUW,
Secretary.

COUNCIL MEETING.

March 28, 8 A. M.

The meeting was called to order by President Praeger.

Members present were: Praeger, Hobbs, Newcombe, Giltner, Walker, Ruthven, Taylor, Jefferson and de Zeeuw.

The report of the Committee on Policy was read by the Chairman of that committee. A motion was made to accept the report as it stood. Seconded. Carried.

A motion was made by Bryant Walker to tender Professor A. A. Michelson an honorarium of $25.00 in appreciation of his lecture at the public meeting the previous evening. Seconded. Carried.

It was moved and seconded that a committee consisting of the Director of the Geological Survey, the Secretary-treasurer of the Academy and the Librarian of the University be appointed to take up with the State Auditing Committee the removal of the restrictions concerning the number of pages of the annual report and to make such improvements in the paper, binding, form and substance of the report as in their judgment is necessary and desirable. Carried.

The following resolution was offered by Professor Newcombe:

Resolved, That the thanks of the academy be hereby extended to Dr. Geo. D. Shafer for his efficient services as Secretary-Treasurer and Editor of the Academy, during the three years of his unselfish activities in these offices. Seconded. Carried.

It was moved and seconded that the following list of applicants for membership to the Academy be favorably reported to the general meeting. Carried.

List of names submitted:

R. A. Turner.
Rachel Benham.
F. A. Spragg.
G. W. Hood.
Geo. Bouyoucos.
Elizabeth Thompson.
W. H. French.
R. G. Hoopingarner.
J. O. Linton.
Arao Itano.
Chas. N. Frey.
R. P. Hibbard.
V. M. Shoesmith.
Harry Musselman.
William Marti.
R. J. Baldwin.
Ruth F. Allen.
D. R. Scott.
A. F. Shull.
E. M. Houghton.
A. H. Povah.
Geo. L. LaRue.
Helen M. Martin.
L. Zae Northrup.
R. F. Sprague.
Chas. H. Merrill.
Jessie McNall.
W. O. Hollister.
W. W. Stewart.
Jefferson Butler.
Karl A. Guthe.
Walton H. Hamilton.
S. McC. Hamilton.
O. C. Glasser.
Ada Kathleen Dietz.
Sarah D. McKay.
Bernice L. Haug.
F. E. McCain.
L. Lenore Conover.

Edgar M. Ledyard was proposed as a corresponding member.

The following resolution was offered by Professor Newcombe:

Be it Resolved, That the Michigan Academy of Science tender to Professor A. A. Michelson its warm appreciation of his courtesy in responding to the request of its Council to deliver an address at the annual meeting of 1912. Seconded. Carried.

A motion was made and seconded to appoint a committee to confer with the people interested in Physics and Chemistry to see whether there is any desire to form a Physics-Chemistry Section. Carried.

The Chair appointed Professor Hobbs and Newcombe.

A motion was made and seconded that the secretary be instructed not to honor bills for assistance presented by the Vice-Presidents after this date. Carried.

RICHARD DE ZEEUW,
Secretary.

COUNCIL MEETING.

March 29, 8 A. M.

The meeting was called to order by the President.

Members present were: Praeger, Taylor, Leverett, Newcombe, Hobbs, Smalley, Pollock, Ruthven and de Zeeuw.

In addition to the people recommended as new members for the Academy at the last meeting of the Council, Miss Bernice L. Haug was also recommended.

A motion was made that the secretary be instructed to inform the Agricultural Section to elect a Vice-President and to send the name to the President for ratification. Seconded. Carried.

The following are the nominations made for Vice-Presidents of the different sections:

Geography and Geology ....R. C. Allen.
Zoology ....Peter Okkelberg.
Botany ....Ernst A. Bessey.
Sanitary and Medical Science ....C. A. Behrens.
Economics ....F. T. Carlton.

Dr. Pollock moved that these names be recommended to the General Meeting. Seconded. Carried.

Professor Newcombe nominated Dr. de Zeeuw as Secretary for the coming year. Seconded. Carried.

Professor Newcombe nominated Mr. Bryant Walker as President for the coming year. Dr. Ruthven nominated Professor E. C. Case for the same office. Mr. Walker withdrew his name. Mr. Walker moved that the Secretary be instructed to recommend Professor Case. The motion was seconded and carried.

Professor Newcombe nominated Dr. Ruthven as Librarian for the coming year. Seconded. Carried.

RICHARD DE ZEEUW,
Secretary.

GENERAL BUSINESS MEETING.

March 29, 9 A. M.

The meeting was called to order by the President.

The feasibility and advisability of having a summer session of the Academy was discussed. Bryant Walker moved that the matter be referred to the Committee on Policy which is to report in regard to this matter at the December meeting of the Council. Seconded. Carried.

The Treasurer's report was read and approved.

The names of the new officers recommended by the Council were read. Dr. Ruthven moved that the Secretary be instructed to cast a unanimous ballot for all as read. Seconded. Carried.

The list of new members recommended by the Council was read. Mr. Walker moved that all be accepted as read. Seconded. Carried.

Dr. Hobbs moved that the old Committee on Policy be retained, except that W. E. Praeger be appointed to succeed Dr. Hobbs as chairman of the committee and that Dr. Ruthven be added as an additional member of the committee. Upon objection from Professor Praeger, Dr. Hobbs modified his motion so as to make Professor Newcombe chairman of the committee instead of Professor Praeger. Professor Newcombe amended the motion so as to include Dr. Marshall as a member of the committee. The amendment was accepted by Dr. Hobbs. The motion as it stood was seconded and carried.

The Committee on Policy is thus composed of the following members: Newcombe, Hobbs, Novy, Reighard, Praeger, Walker, Ruthven and Marshall.

The Librarian's report was read and accepted.

A motion was made to adjourn. Seconded. Carried.

RICHARD DE ZEEUW,
Secretary.

REPORT OF THE TREASURER.

Expenses:

Stamps and envelopes	$19 47
Drayage	1 30
Honorarium to A. A. Michelson	25 00
Assistance in mailing preliminary report	1 00
Assistance in mailing annual program	1 00
Lawrence & Van Buren Printing Co., for printing of preliminary reports and annual programs	25 00
C. S. Robinson, for stenographer	2 25
Robert Smith Printing Co., for 3,000 letterheads	12 55
Window signs and cards for the annual meeting	4 85
Janitor at the annual meeting	2 00
Total	$94 42

Receipts:

Balance received from former Treasurer, Geo. D. Shafer, Dec. 22, 1911	$68.29
Other receipts, from Dec. 22, 1911, to June 3, 1912	148 50
Total receipts	$216 79
	94 42
Balance	$122 37

COMPLETE LIST OF PAPERS AND ADDRESSES PRESENTED AT THE EIGHTEENTH ANNUAL MEETING OF THE MICHIGAN ACADEMY OF SCIENCE.

1. Presidental Address: Plant Breeding, W. E. Praeger.
2. A brief report from the director of the Geological and Biological Survey of Michigan concerning the work of the Survey for the year, R. C. Allen.
3. Report of the Chief State Naturalist, A. G. Ruthven.
4. A Symposium upon Recent Views Concerning the Nature of the Earth's Interior.
   The View of an Astronomer, W. J. Hussey.
   The View of a Physicist, A. A. Michelson.
   The View of a Geologist, Wm. H. Hobbs.
5. Public Address: Iridescent Colors of Birds and Insects, A. A. Michelson.
6. Unreported Michigan Fungi for 1911, C. H. Kauffman.
7. Preliminary List of Michigan Mosses, C. H. Kauffman.
8. An Optimum Culture Medium for a Fungus, J. B. Pollock and Rose M. Taylor.
9. A Working Key to the Species of Solidago Occurring in Michigan, Chas. H. Otis.
10. A "Clearing House" for Reports on Fungus Distribution, E. A. Bessey.

10½. Demonstrations of Endotrophic and Ectotrophic Mycorhiza, W. B. McDougal.

11. Behavior of Main and Lateral Stems When Displaced from their Normal Position, F. C. Newcombe.
12. Indications of Induced Apogamy in Onoclea Struthiopteris, Elizabeth D. Wuist and C. H. Kauffman.
13. The Measurement of Tree growth, C. L. Hill.
14. The Use of the Quadrat Method in Ecological Field Work, H. A. Gleason.
15. Plant Succession on Lumbered Districts, Fred A. Loew.
16. An Aspen Association in Northern Michigan, B. E. Quick.
17. The Successional Relationships of the Plant Associations of the Douglas Lake Region, F. C. Gates.
18. Some Studies on the Structure of Hydrophytic Leaves, Geo. L Keenan.
19. The Plant Diseases of Michigan, G. H. Coons.
20. The Anthropography of North America, M. S. W. Jefferson.
21. Some Considerations Concerning the Place and the Origin of Lava Reservoirs, Wm. H. Hobbs.
22. Recent Data Relating to the Structure of the Pre-Cambrian West of the Iron River District, Michigan, R. C. Allen.
23. The Age of the Keweenawan Series, A. C. Lane.
24. Some Interesting Changes in the Optical Properties of Crystals with Temperature, E. H. Kraus and L. J. Youngs.

25. Additional Notes on the Geology of the Detroit River Area, Thomas Nattress.
26. Notes on the Geology of the Jemez Quadrangle of North Central New Mexico, E. C. Case.
27. Review of the New Geological Map of North America, E. C. Case.
28. Deformation of Beaches in the Lake Superior Basin, Frank Leverett.
29. Topographic Maps of Michigan, Frank Leverett.
30. The Origin of Continental Forms, II, Howard B. Baker.
31. Maps of the Old Distributaries of the St. Clair and Detroit Rivers, F. B. Taylor.
32. The Ethical Implications of Economic Theory, Walton H. Hamilton.
33. Scientific Management and the Wage Earner, Frank T. Carlton.
34. The Status of Workmen's Compensation Legislation, Edward H. Ryder.
35. The Cost Theory of Railway Rates, Henry C. Adams.
36. General Discussion of the Report of the Michigan Commission of Inquiry into Taxation.
37. Results of the Mershon Expedition to the Charity Islands, Lake Huron: Amphibians and Reptiles, Crystal Thompson and Helen Thompson.
38. Some Bird and Mammal Records for Michigan, N. A. Wood.
39. Directions for Collecting and Preserving Specimens of Reptiles and Amphibians for Museum Purposes, A. G. Ruthven.
40. The Breeding Birds of the Charity Islands, Lake Huron, with additional Notes on the Migrants, N. A. Wood.
41. On the Wisconsin Wood-Frog, Helen Thompson.
42. The Pickerel Frog, Rana palustris LeConte, in Michigan, Crystal Thompson.
43. Notes on the Phyllopod Crustacea, A. S. Pearse.
44. Notes on Michigan Crustacea. 2. A New Michigan Asellus, A. S. Pearse.
45. External Conditions and the Growth Period in the Eggs of Hydatina senta, A. F. Shull.
46. The Influence of Egg and Sperm in Inheritance of Egg Characters in Hydatina senta, A. F. Shull.
47. The Origin of Continental Forms: 3. A Preliminary Note on the Faunal and Floral Relations, Howard B. Baker.
48. A Collection of Mammals from Osceola County, Michigan, O. J. Wenzel.
49. The Pawlow Method in Animal Psychology Applied to the Fresh Water Snail, Physa, Elizabeth Thompson.
50. A Demonstration of the Skeleton of a Cotylosaur from New Mexico, E. C. Case.
51. Pseudohermaphroditism in the Brook Lamprey, Peter Okkelberg.
52. Factors that Determine the Location of the Borings of the Yellow-bellied Sapsucker in the Yellow Birch, Margaret W. Taggart.
53. Report on the Zoological Work Done at the Biological Station of the University of Michigan at Douglas Lake, Jacob Reighard.

54. Cestod Parasites of Fresh Water Fish, G. L. LaRue.
55. New Methods of Making *in toto* Preparations, G. L. LaRue.
56. The Distribution of the Ancylidae, Bryant Walker.
57. Preliminary Report on the Ecology of the Mollusks of the Douglas Lake Region, H. Burrington Baker.
58. The Origin of the Germ Cells in the Toad Fish, Emory Sink.
59. The Application of Calorimetric Methods in the Study of Embryology, O. C. Glaser.
60. Notes on the Amphibia and Mammals of Gratiot County, Michigan, H. M. McCurdy.
61. The History of the Germ Cells in the Paedogenetic Larva of Miastor, R. W. Hegner.
62. Check-List of Michigan Lepidoptera: I. Rhopalocera (Butterflies), W. W. Newcomb.
63. On Some Amphibians and Reptiles from the State of Vera Cruz, Mexico, A. G. Ruthven.
64. Prevention of Infant Mortality, Francis Duffield.
65. Fever: Its Nature and Significance, V. C. Vaughan.
66. Fermentation of Brine Pickles, Otto Rahn.
67. Bacteriological Studies on the Keeping Qualities of Butter, C. W. Brown.
68. The influence of Certain Acid-Destroying Yeasts upon Lactic Bacteria, Zae Northrup.
69. Practical Milk Inspection, W. A. Price.
70. (1) Standardization of Rabic Virus.
    (2) The Production of Immunity by Means of Dialyzed Rabic Virus.
    (3) The Passage of Rabic Virus Through the Berkefeld Filter, J. G. Cumming.
71. Effects of Dialysis on Serum, C. A. Doty.
72. The Virulence of Cultures of Tr. Brucei, C. A. Behrens.
73. The Viability of the Rat Ultra Virus, W. A. Perkins.
74. Immunity by Berkefeld Filtrates of Cultures of T. Lewisi, R. Chambers.
75. Immunity Against the Ultra Virus of Rats, W. A. Perkins and R. Chambers.
76. The Toxic Products Formed in the Cleavage of Casein, R. W. Pryer.
77. The Standardization of Disinfectants, M. L. Holm.
78. The Relation of B. fusiformis to Membranous Angina, Q. O. Gilbert.

PLANT BREEDING.

As man eats plants, or other animals that live on plants, and as man must eat to live, the plant relation is the most fundamental in the history of the race. And as man advances in civilization and adds a hundredfold to his necessities as well as to his comforts and luxuries, this relation remains as dominant as ever tho far more complex. The course of history, the evolution of society, the character of civilizations can better be interpreted in terms of this primary botanical relationship than by any other one factor. Primitive men, like the savages of the tropical jungles, are individually and socially at the mercy of the plants that surround them. More advanced but stationary societies exist where peculiar botanical conditions urge man to hopeless effort, as the Bedouin dependent on the desert oasis or the Eskimo whose only available food supply is the animal life that relies on the algae of the arctic seas for subsistence. Civilization began in regions where natural conditions were poor but where cultivation or irrigation offered a large and certain crop. Thus forced to work for a definite end all the great nations of antiquity arose in semi-arid countries Persia, Assyria, Egypt, Mexico, Peru led the way, till man learned to work not by necessity but by choice, when the power moved to lands of greater natural fertility or to those that controlled the trade routes. And so with the tribes and nations of all climes and ages, as they gained control of the plants or the product of plants so might they be prosperous and progressive. "The only conquests that have endured," says the Italian historian Ferrero, are those of the plough."

It is perhaps a little humiliating to think that many of our useful plants and most of our domestic animals were brought into subjection before the dawn of history or even of tradition. Somewhere in the stone or bronze age the work was done and the centuries since cannot show its equal. But what is more strange, in some way those primitive men so changed the animal or plant that it was a new variety, made by man for his own needs. Often all trace of the wild ancestor and the place of its origin is lost. Where did our cat or dog or horse come from, our barley, apple or turnip? We can only speculate. Who first saw an ear of corn? The Indians cultivated maize over a wide area when America was discovered, but no such plant has been found in a wild state and it is only supposition to trace it to a cross between certain Mexican grasses. Perhaps the mystery of the origin of our greatest crop will never be solved.

To separate intentional plant breeding from incidental or accidental is often impossible. It would seem that the art has been practiced by man quite unconsciously and without further aim than the immediate crop. The ultimate result is quite uncertain but often very remarkable.

On the sea-cliffs of Europe there grows a small straggling plant known to botanists as *Brassica oleracea*, tho the leaves are edible it is an unpromising looking species for the garden and he must have been a daring and imaginative man who first planted a cabbage. Yet it was

probably in cultivation before the final western movement of the Aryan race and in the time of Pliny several varieties were recognized in Italy alone. Today from such beginnings, we have among others the cabbage with its terminal bud enormously enlarged, the kale with small bud but large curled succulent leaves, the brussels-sprout with small lateral buds crowded on the stem, the kohl-rabi with the stem itself round and edible, the cauliflower, perhaps the most extraordinary of vegetables, with the small thin flowers of its wild ancestor developed into a great solid white edible mass of stems and buds.

Even in modern times horticultural forms have originated and become widely spread whose story is already lost. The cacti are an American group of plants now common throughout the dry regions of the world, especially those with edible fruit known as prickly pears. The settlement of our southwest has brought these plants into recent prominence and the Department of Agriculture set itself to find a spineless cactus suitable to our conditions. There are now growing in its experimental gardens a score of spineless cacti gathered from every continent, the Mediterranean region furnishing the greater number and the Island of Malta a particularly fine variety without spines on its stems or seeds in its fruit. It is believed about ten of these forms will be of permanent value in this country. But how did these arise? In no case can the growers throw any light on their history. They have not been produced by any horticulturist nor even by peoples acquainted with scientific plant breeding. The Mexicans took pride in their spineless cacti before the time of Columbus and it is probable that most of the forms came from there, but it is possible that some are endemic.

There are few plants that furnish a greater variety of products to a primitive people than the cocoanut palm. The meat, shell and husk of the nut, the bud, leaves, flower-bud, wood, roots all have uses. Probably of American origin it is now cultivated throughout the tropics often by barbarous peoples with crude ideas of agriculture. Yet this one species has been broken into many forms, and about fifty of these varieties are recognized in the Malayan region alone.

While domestication in itself has led to the amelioration of plants it is not to be supposed that in ancient times the propagation of selected varieties was ignored. Selection among animals for breeding purposes is mentioned by Homer and in the book of Genesis, but I do not know of the specific notice of plant breeding at any such early date. Vergil tells of the continuous selection of the best wheat for seed, but too often in history has the husbandman's work been despised and his doing unrecorded. But with the revival of learning the interest in this art also was awakened. To illustrate let us review the history of our carnation. It is mentioned by Thephrastus along with the iris, rose, violet and narcissus as cultivated by the Greeks who gave it the scientific name it still bears—Dianthus. When its original lilac color was changed to pink and then broken into red and white, we do not know but it was previous to the sixteenth century of our era, at which time its cultivation greatly increased. The gardeners of Italy, France, Holland and England contributed so many varieties that Gerard writing in 1597 says, "A great and large volume would not suffice to write of every one at large and in particular." In 1613 Besler figured carnations grown in Switzerland three and one-half inches across. In

1702 John Ray catalogued 360 distinct kinds and in recent years Vilmorin states that some dealers offer as many as 2,000 different kinds.

The past century has seen a greater increase in the number and excellence of cultivated varieties than all the preceding centuries. Plants long domesticated have been wonderfully developed. If we contrast a list of American grown fruits published by Coxe in 1818 with a similar list in 1908—ninety years later—we will realize this:

Apples	133	2,138
Pears	65	2,567
Peaches	38	447
Plums	18	522

A comparison of the grains, vegetables, or flowers would show a similar increase. We have here a store of wealth unknown to our forefathers. But what is most encouraging is that the discovery of new forms has steadily increased. In the future the first decade of the Twentieth Century will be looked upon as epoch making in the history of plant breeding. Let us consider the reasons.

First, I would place coöperation and coöperative methods. The people as a whole are interested in the movement, the increase of rural wealth and the conservation of our resources are national questions. The Department of Agriculture is at work throughout the land, each state has its experiment station and agricultural college. A large number of trained experts can be put to work on each and every problem. The graduate schools of our universities contribute largely to the more theoretical side. The exchange of knowledge is world-wide, no man need work alone and every effort is made to spread the results of work rapidly, accurately and cheaply to all who can profit thereby.

Secondly, the opening of little known regions of the earth and rapid transportation promise amazing results in the near future, tho indeed much has been already accomplished. The colonists had to bring their plants and seeds from Western Europe where the climate is totally different from that of our Eastern States and the methods of cultivation unsuited to our conditions. Under these circumstances what the American breeders accomplished is surprising, and as the Star of Empire moved westward into new lands and climates, new plants were developed to meet the needs. The long list of names of American plant breeders deserves a conspicuous place in our Hall of Fame, tho they are now mostly unknown except to the specialist. As early as 1818 in Coxe's list, before mentioned, of 133 varieties of apples 68% were American productions and at the present time of over 2,000 varieties grown in the States less than 1% came from abroad if we exclude the recent Russian importations.

But today the plants of the world are available for experiment. Every corner of the earth is ransacted by agents of our government or of private firms. Whatever the climate or soil may be the suitable species are imported and propagated. The experiences of other lands are available. We watch the results of foreign breeders and import their creations. The immediate results have been wonderful, but the opportunities for the future are greater far.

Thirdly, the opening years of the present century were marked by

the publication of researches in heredity, in hybridity and in variation of quite unprecedented importance. The practice of plant breeding had in the past been purely empirical. No laws seemed to govern the appearance of varieties or the result of crosses. The breeder searched for improved races among a confusion of forms quite uncertain as to what he might find, or when found, if the improvement could be fixed. The evolution of our domestic plants is more creditable to human patience than to human knowledge. But tho we have been working in the dark, light is breaking. The extremely complex laws that govern the evolutionary process are now partially known, already they are influencing practice and when more fully understood the effect will be of the greatest importance and value to mankind. It was the evolution of our domestic races, the artificial selection of plant and animal breeders that was so largely used by Darwin to establish the law of natural selection and the theory of organic evolution. If practice can thus contribute to theory reciprocity is to be expected, for plant breeding is simply evolution under partial human control.

The practice of plant breeding in its simplest terms is the selection of desirable varieties. The factors are variation and selection, and of these variation is the more critical. Selection is the human factor but ineffective without variation to work with. Before taking up variation we may satisfy ourselves as to man's ability as a selector.

The power of discrimination may be developed in the man who lives among his plants to an extent almost beyond belief. To find among thousands of young plants the slight variation which may lead to an improved strain is no easy task. Often plants must be selected not by one but by a combination of characters. Still more remarkable is the ability to select plants not by the desired quality itself but by associated characters. Children who work in the flower gardens of France are able to separate the stocks that will have single or double flowers when they are still seedlings, even tho the seed came from the same parent. Quinces have been selected before they had either flowers or fruit. Verlot mentions a gardner who could distinguish 150 kinds of Camellia when not in flower, and according to Darwin, it is positively asserted that the famous old Dutch florist Voorhelm, who kept about 1,200 varieties of hyacinth, was hardly ever deceived in knowing each variety by the bulb alone.

For successful work the trained eye will not suffice but an ideal must be in the mind of the breeder. The selection must be made, as opportunity offers, towards a desired type. The end to be attained may be a development, a suppression, or a change. It may be in color, size, strength, height, shape, flavor, perfume, hardiness, time of maturing, resistance to disease, resistance to drought, absence of spines, doubling of flowers, or what not. And no matter what it may be still the plant must be considered as a whole, for a single weak point may spoil a dozen good ones.

But the methods of modern agriculture will not long be satisfied with simple observation. At the Svaløf experiment station—which has become a model for breeding of grains to the whole world—the most exact methods of weighing and measuring are used, the qualities are all subject of measurements and tests by various tools and instruments, the vernier and the microscope are none too fine for the purpose. The

qualities, whatever they may be, are all expressed in figures. The amount of bookkeeping is very great. In the year 1900, according to de Vries, some 3,169 varieties were in culture. The records embrace the complete botanical description of each new sort from its germination till the time of harvest, with all the details required for controlling its constancy and uniformity, and for the study of all those qualities on which the introduction into general agriculture will ultimately depend.

It is evident that the chance of a fit variety turning up is proportional to the number of plants tested, the larger the number of rejected unfit the greater the chance of rapid progress. Thus to produce the Burbank Paradox berry 40,000 blackberry and raspberry hybrids were produced and grown until the fruit matured. Then from the whole lot a single plant was chosen as the best, all others were uprooted and burned. In the trial grounds of Dixon Bros. of Belfast, Ireland, of a total of about 1,300 choice hybrid seedling roses raised each year perhaps ten new kinds worthy of preservation may be expected and of these only one may be suited to the American trade. At such a cost have the "Killarney," the "Betty" and a score more of our best roses been produced.

Even the chemist is now an aid to the selector. Our annual product of 2,500 million bushels of corn is used for a great variety of purposes, stock feeding is the chief but over 100 different commercial products and about fifty kinds of food are derived from corn and its various constituents. For many of these purposes a special part of the grain is desired. For fifteen years the experiment station at the University of Illinois has been breeding corn for high and for low oil content and for high and for low proteid content. In 1908 the races thus produced yielded respectively 7.19% and 2.39% of oil, 13.94% and 8.96% of proteid. Thus the possibility of breeding for chemical content has been demonstrated.

But all the improvements in methods and extent of selection would be of no avail unless there was variety to make it effective. Till the variation occurs man is helpless. He cannot as yet make plants to order. When we speak of plant creations we mean nothing of the kind. All man can do is to select, sort, arrange, combine, the qualities have to be created for him through variation. It is evident that the key to the situation lies here and that future progress depends on an increase in our knowledge of the nature of variation. As difference from parents constitute variation and as the preservation of a valuable strain depends on resemblance to parents, the whole problem of heredity is involved.

As an important part of practice we must here notice that in the majority of our perennial plants vegative propagation can be used. So grafts, buds, stem, root, and leaf cuttings, layers, runners, bulbs or tubers and other methods are used to propagate and the uncertainties of generation avoided. Many a clone has arisen from a single individual and is still genetically one, tho grown and disseminated as thousands of separate plants.

What then is variation? It used to be defined as a departure from the type of the species but when we ask what the type of the species may be, we find we are talking of an abstraction. Prob-

ably no two individuals are ever quite alike, variation is universal and a "species of plant is a judgment of man." Still the conception of species is too useful to be lost. Species do exist, but as averages, norms or even conditions and a sport, form, variety or mutation simply means the extent and nature of the departure from the norm.

Now as the characters of a plant—other than those acquired during life—are generally inherited, the selection of the seed of those plants that have desirable variations and the rejection of undesirable seed will result in a better average crop. We can commonly move the average in any direction in which variations occur and by continuous selection maintain it there. This is plant breeding in its simplest form and as such has been practiced for centuries and is still in common use. The method ignores the discoveries of recent years but its great results entitle it to respect and may justify its continuance.

There is one method that has been practiced for centuries by which man has caused variation and increased his chances of favorable selection. This is hybridizing. Most of our cultivated plants are hybrids. Often we do not know the parent species and when we do know them we are ignorant of the proportions in which the ancestral strains exist. Probably cross pollination was often an accident as far as man was concerned. In practice it has been and still is largely an empirical subject. Breeders have been able to construct an average of probabilities as to what will and what will not occur in a given case; but the given case may contradict all the probabilities without apparent cause. We do not know what forms will hybridize or when this is accomplished if the hybrid will be fertile. Crosses often increase the vigor of the strain, hybrids between more remote forms are less likely to show this and may deteriorate. When crossing has been accomplished we do not know what we may get, because of our ignorance it is a matter of chance. What we are pretty certain to get are a lot of new combinations from which selection can be made, and that multiply many fold the opportunities of the breeder.

As an example of this method the history of some well known hybrid will be of interest. The sweet pea seems to have been first cultivated in 1699 by Father Franciscus Cupani, a botanist of Sicily, where a purple and a white species are indiginous. Seeds were sent by him to England and elsewhere. As early as 1750 they had become an article of commerce. Two new species were brought from the island of Ceylon, a red and a pink and white still known as the "painted lady." From these four wild species it is probable all our sweet peas are derived. In 1795 a London seed catalog offered five varieties. Forty years later two more—a striped and a yellow—appeared. Not until 1860 do we find any further advance, when a blue-edged variety known as the "Butterfly" was added. The next few years gave us the "Invincible,"—a scarlet,—the "Crown Princess of Prussia,"—the first flesh pink, "Adonis,"—a rose pink,—and a few others of less worth. In 1876 Henry Eckford of Shropshire, England, took up the sweet pea problem. Starting with a few common sorts it was seven years before he had anything to offer, but by 1898 he had put out seventy-five named varieties, the result of twenty-two years selection. Others were also at work and so from small beginnings the marvellous variety of size,

form, and color of our twentieth century sweet peas was produced.

Our sweet peas are the result of promiscuous hybridizing and continuous selection, but crossing for definite ends has often been practiced with success. As for instance, when the hardy *Citrus trifoliata* of Japan is crossed with the orange of commerce thus producing the "citrange." This fruit is not as large as the orange but of excellent quality and can probably be improved by selection. As these plants will endure 20° of frost the range of orange culture will be extended northward several hundred miles.

We cannot stop longer to consider hybridization though it has been productive of our most useful and beautiful plants. We have already noticed the unexpectedness of its results. Its eccentricities seemed endless. It was lawless. But with the opening of this century all has been changed. A law—for such I believe it may properly be called—was made known that promises to bring order out of chaos and in time furnish methods to the breeder, of quite unprecedented importance.

Need I repeat the oft told tale, one of the tragedies of science? How for thirty five years the published results of the work of August Mendel remained unappreciated and forgotten and it was not till long after the death of the unknown abbot of Brünn that his great discovery startled the biologic world.

Nor need I repeat to this audience the nature of Mendel's experiments nor the important generalizations to which they lead. He it was who first applied careful experimentation to problems of heredity and the results achieved and wide-reaching theories founded on them have been confirmed and extended by many followers in the past decade. Mendel's law became known in 1900. The method of experiment as applied to problems of genetics was soon to bear further fruit. The following year the "Mutation Theory" was published, the next great step in making the art of breeding a science. That "sports" and varieties that bred true had been known from a very early time is certain, but confused ideas as to variation among breeders and a superstitious devotion first to fixity and then to fluidity of species among biologists prevented their importance being recognized. It remained for Prof. Hugo de Vries of Amsterdam by his elaborate researches and experiments to clear up the confusion, classify the different kinds of variation, define mutation and unite characters and establish mutation as the chief material for the plant breeder.

A mutation is a definite variation in the character of a plant that is at once inherited. These occur rarely—in most species they have never been observed, in a few they are comparatively frequent. A plant may mutate in different ways and the same species may mutate in the same way at different times and places. The new forms will cross with the parent or with each other exhibiting the laws of hybrids. A mutation, in short, is a species whose origin we know.

The theory of unit characters found in the work of Mendel and of de Vries an endorsement that if it did not establish it as a fact at least placed it in the position of a working hypothesis. This is the conception that the characters of living organisms are due to definite, indivisible units whose identity persists from generation to generation. Unit characters or determinants are to the biologist what atoms are to the chemist, but we know much less about them. Matter is conceived

of as made up of atoms and its character is determined by the nature and arrangement of the atoms of which it is composed, so the character of living matter is settled by its determinants. Most visible characters of plants are compound and made up of several or many units, how many we do not know, but in hybridizing the true nature of a character may come out and not a few unit-characters have been isolated. A mutation is, therefore, a congenital change in the determinants. It is by aid of this theory of unit characters that much of the best work in plant breeding is now being done.

The history of the origin of our fruits will at once convince us that the great majority have arisen, not by repeated selection but by the isolation of a single plant. Thus the Tyson pear was a native seedling found in a hedge near Philadelphia. The Seckel, a single tree on waste land four miles from the same city. The Sheldon, an accidental seedling on a farm in Wayne county, New York. The Concord grape, a vine said still to exist at Concord, Mass., and so on with most fruits whose history we happen to know. Our flowers tell the same story. The "crimson-eye" hybiscus was found in a swamp in New Jersey and is probably a mutation of the common pink species from which it differs also in tint of leaf and shape of seed-pod. From time to time a peculiar dwarf plant appears among ordinary sweet peas—this low bushy form is known as the "Cupid" and is evidently a mutation. It breeds true and no amount of selection of the shorter sweet peas will ever develop the "Cupid." Ordinary variation will not reach it, mutation must occur. Doubtless many a genus of plants, both wild and cultivated, is a complex of species, mutations, and varieties crossed and recrossed in genetic tangle. Such are probably our asters, our sunflowers, our grains and others that are either a constant nightmare or a perennial delight according to the temperament of the taxonomist. Our wheats originated in Eurasia, the various tribes carried different species with them into Western Europe. Our modern wheat is a mixture of these species with the results of thousands of years of cultivation, variation and selection superimposed. Races are mixed and improvement has only been maintained by continuous rigorous selection.

Now it is evident that if an improved race appeared as a mutation and it were isolated and multiplied so that no crossings occurred we would have at once an improved strain that would breed true, evidently a surer and a quicker method than continuous selection.

The first men to use the principle of initial selection with isolation were Le Contour of Jersey and Patrick Sheriff of Scotland. As early as 1819 Sheriff had noticed a single plant of wheat of fine quality and much branched. The seeds were saved and sown separately. In two generations he had enough seed to offer it to the trade as the "Mungoswell" wheat. To this day it is grown in Scotland, England and France and recognized as one of the better wheats. Sheriff continued his work for over half a century bringing out about a dozen new varieties of wheat and oats and in 1872 he published a little book for private circulation describing his method of work.

Sheriff had no theory to offer and perhaps for that reason his practice had little weight. The old method was still used, more perfect in detail, more extensive in application. The Germans especially carry-

ing it forward with great persistence and success. It remained for Dr. Hjalmar Nilsson, head of the Swedish Experiment Station at Svalöf, to rediscover the method of Sheriff and Le Contour, realize its scientific importance and place it on a firm, practical basis. This method, established at his station since 1893, has placed him at the head of grain breeders and made Svalöf the model for experiment stations the world over. We thus have agricultural practice in accord with biological theory.

The method of isolation of a single plant is probably of wide application. Many species of plants both wild and cultivated are now known to be made up of a number of subspecies freely crossed among themselves. These elementary species or biotypes are of very great significance. They breed true and in self-fertilizing plants can be isolated as pure lines when their real nature is shown. Once the pure line is established we have a very definite unit which holds its characters from generation to generation, and defies all powers of selection, for the fluctuating variations exhibited by individuals of the biotype are not inherited. Thus we have revived the fixity, not of species, but of biotypes, or rather of the genes which give its character to the biotype.

What have the plant breeders been doing? Brilliant as is their success it has been founded on a misunderstanding of the facts. The basis of artificial and also of natural selection was the variations which all individuals of a species showed, and which were supposed to be transmitted from parent to offspring. The only subject of dispute was whether characters acquired during life were inherited, a question which seemingly must be answered in the negative. Now it seems that this variation is a mingling of two contrasting kinds, the fluctuations, which are not inherited, and the changed unit-characters forming mutations or new biotypes and that pass, not from, but rather *thru* generation to generation unaltered. A species may, therefore, consist of a large number of biotypes, promiscuously crossed and their dividing lines further blurred by fluctuating variation. The selector instead of changing the position of a norm has really been sifting out fixed biotypes and been changing the average numbers of the constituents.

The breeder does not always desire to produce a pure line, even if he could. It is probable the particular combination of characters that make his ideal is only to be found in a "blend" or "cross," as he would term a heterozygous genotypic constitution. Here also comes in the well known fact that crosses often exhibit a greater vigor and better growth than either of the parents. It is certain that the best results in some instances, as with corn, can only be attained by the maintenance of heterozygous forms and this presents a problem to the breeder of great complexity, as under these circumstances simple selection would tend to make the strain "run out" as we say, and so defeat its own ends. The history of corn breeding is worthy of a detailed notice impossible to give here. The success of the old continuous selection method as exemplified by the Illinois work already alluded to, the improved ear-to-row centgener method, the recent fine work of East and Shull designed to identify the genotypes and then maintain a heterozygous strain, all this shows the growth of the scientific method and the triumphant application of biologic theory to matters of our common life. And let us note with pride that the earliest work done in corn improvement

by crossing was in 1876 by Dr. W. J. Beal, the first president of this academy. On the basis of present accomplishment we are safe in claiming, when once the improved methods are in general use, an increase in value of our corn crop of $300,000,000 without additional acreage or labor.

The plant breeder then is a sorter and arranger rather than a creator. the only hope for something new seems to be in the occurrence of a mutation. Large changes, such as those of Oenothera used by de Vries, seem to be rare enough, but possibly mutations smaller in amount may be quite frequent. If such occurred within the extremes of existing genotypes or of fluctuations they could be recognized only with the greatest difficulty, and yet might be used unknowingly by the breeder. It is certainly very remarkable how often the selector has started to attain a non-existent ideal and has got there. Nor must we lightly set aside the universal belief of breeders that cultural conditions induce heritable variations. We do not know what induces mutation but de Vries believes external cause to be the more probable.

Culture widely modifies the external conditions, crossing the internal, even to affecting the chromosomes of the zygote. In the garden, if anywhere, there would seem to be a chance for permanent changes in the unit-charcters of the plant. When we realize the basic importance of variation, and our own inability to control it, some very recent experiments are of surpassing interest. These are associated in this country with the names of Tower and McDougal, the former working with insects, the latter with plants. The results are the production of new forms of plants and animals by external influence acting directly on the germ cells. This has been accomplished by exposing the cells to such influences as temperature, moisture, radium or chemicals. Let us take the work of McDougal. He has injected chemicals into the ovary of certain plants as Raimannia, Oenothera, Cereus and Pentstenon in such a way that both egg and sperm are brought into contact with them. This act often results in the destruction of the seed, often has no effect, but occasionally seeds are produced that grow into plants sharply distinguished from the parents. But the most interesting thing about these new forms is that they breed true and—though no further stimulus is used—do not revert to the original type. They are true mutations, the hereditary qualities have been changed by a direct act of man. These experiments are very new, their interest is as yet purely theoretical, but they may open possibilities whose practical importance can hardly be overestimated.

The science of plant breeding has by no means reached a point where we can accept any one theory as final. The time is ripe for suspension of judgment. In 1874 Tyndall wrote of evolution, "The first step only towards experimental demonstration has been taken. Experiments now begun might a couple of centuries hence furnish data of incalculable value which ought to be supplied to the science of the future." But a fraction of the time set by that optimistic radical has passed and we should resent any attempt to close debate thus early in our work. Variation has been classified and it is certain that the classification will be of great practical importance, but we do not know whether these groups have even as great validity as the conception of independent species which served biology so long and so well. They may inter-

grade or be conditioned on their environment. Theories seem to differ largely in matters of nomenclature and of emphasis. Darwin emphasized small saltations that were heritable, de Vries large saltations and fluctuations, the latter not being heritable. The breeder will use them all for even a fluctuation may be propagated as a clone. Unit characters will have a place in all sound work, but we do not know when a character is a unit, behind the molecule is the atom and now we have the electron. Variations that are heritable are probably discontinuous, but if the break is sometimes so small that it cannot be detected, and we have been told that this is so, the practical worker may be forgiven for treating the variation as continuous. Mendel's law is the greatest contribution to genetics in half a century, but it does not seem to be applicable in all cases. We hear of its modification by external conditions, and as fertilization is subject to such influences, as for instance when with the aid of chemicals we induce hybribity between widely differing organisms or development of the egg without the sperm, we should be prepared for vagaries in the results of crosses. The genotype theory needs further confirmation. We are assured that a biotype is as definitely recognizable as a cat or a dog. This may be true, but though we have known cats longer than biotypes, we have as yet no all-inclusive cat theory. And besides are we prepared to answer the question, "What is a cat?" It has been said that effects of environment are not inherited. A question mark has to be placed with that statement in the light of recent work, and till we get an organism without any environment, how are we to know what the effects of the latter may be? Larmarckism we are told is dead, but somehow, its ghost will not be laid.

But the great thing is that in the present century, young as it is, we have learned so much. That we have applied experimental methods to the great problems of life with such success, that a control of the plants greater than man ever enjoyed before has been secured, that this has been accomplished by the cooperation of many workers and supported by a genuine public interest. To the many who say—I believe unjustly—that we live in a material age when the higher things of life are neglected, the history of biology will furnish a refutation. Darwin's epoch making work revolutionized our science, but not till its effects on religion, philosophy, history, sociology and our whole mental and spiritual life had been discussed for nearly half a century did the evident possibility of using evolution for material progress receive attention. Now the time seems ripe for those principles to be applied to more practical affairs, to contribute to our material well-being as they already have to our intellectual. To add to our wealth, our comfort, our health, to the beauty and the joy of life. The great evolutionary river of life sweeps by us, flowing from the unknown to the unknown, with powers and forces in its mighty current we as yet cannot measure. What powers may be turned to usefulness, what desert places may be made fertile by even a partial control of that current is also unmeasured and unknown. But what has already been accomplished by clumsy and primitive means, gives confidence to the prophecy of mighty works when organized knowledge and exact methods shall be used.

WM. E. PRAEGER.

Biological Field Work of the Michigan Geological and Biological Survey.

PROGRESS OF THE GEOLOGICAL AND BIOLOGICAL SURVEY OF MICHIGAN.

R. C. ALLEN, DIRECTOR, AND A. G. RUTHVEN, CHIEF FIELD NATURALIST.

Geology and Topography by R. C. Allen.

Members and Friends of the Michigan Academy of Science:

I am informed by your committee on policy that a brief recital of the progress of the Michigan Geological and Biological Survey would be henceforth acceptable as an annual feature of the Academy of Science reports. I am in hearty accord with the spirit of this idea and welcome the opportunity of thus keeping members of the Academy in closer touch with the purposes and accomplishments of the Survey. Every member of the Survey is a member of the Academy, as is also, with one exception, every contributor to the Survey publications in recent years. The functions of both organizations are, in the main, similar, but the Academy has the wider field, embracing all of the sciences, the Survey a narrower field, limited to geologic and biologic investigations within the confines of the state as specifically set forth in the laws by which the department was created. The Survey will complete in 1912 the 43rd year of its continuous existence. The support which the state has given it has not been large, but it has nevertheless been steady and not fitful, enabling the work to be carried forward from year to year with modest but definite progress.

Brooks has recently shown that the character of the geologic investigations carried on by governmental surveys has been trending steadily toward an overwhelming emphasis of applied geologic science. In 1911, 98% of the publications of the U. S. Geological Survey were classed by Brooks under the head of applied geology. The work of the various state geological surveys reveals a like conspicuous trend toward utilitarian, as distinguished from the purely scientific functions of these organizations. The Michigan Survey is not only in sympathy with this movement, but is in active pursuit of the policy of bending its resources to distinctly and primarily useful purposes in the survey of the state. Investigations of purely scientific or purely educational character are not, however, neglected. It is certainly true that every fact of science has somewhere and sometime a practical application, and it is also true that geology in the service of industry is necessarily none the less scientific. In many cases the results of geologic investigations have both immediate practical and purely scientific value, but too often one or the other of these values is obscured or subordinated by the form of presentation. The purely scientific in geology appeals to a very limited number of people, but applied geology, properly presented, is geologic science in the service of industry, and is useful to a very considerable proportion of the intelligent masses.

GEOLOGY.

Recent Publications. One of the recent successful applications of geologic science to an economic purpose is effected in our Publication 7, Surface Geology of the Northern Peninsula of Michigan, by Prof. Frank Leverett. This work includes a map of the surface or soil formations and a brief explanatory and descriptive text discussing the character and general soil value of the various classes of formations. The report is designed to convey accurate and reliable information concerning the land, its soil values and adaptability to agriculture, while the philosophic and purely scientific aspects of the study are subordinated.

The reception accorded to this work is indeed gratifying and the demand has necessitated the printing of nearly 100,000 copies of the map, of which number 76,000 constitutes a private edition paid for by the Upper Peninsula Development Bureau. A similar volume and map dealing with the surface or soil formations of the Southern Peninsula is in preparation by Prof. Leverett, under co-operative agreement with the Director of the U. S. Geological Survey. We have authorized two private editions of this map in advance of its appearance, and it is probable that there will be required some 75,000 copies to supply the demands which are expected to be made.

There has appeared recently Publication 5, by Prof. Wm. H. Hobbs, a bulletin on the glacial and post-glacial uplift of the Michigan basin, and a resumé of earthquakes in Michigan, and Publication 4, prepared under the direction of the Chief Field Naturalist, being a report upon the biology of the sand dune region on the south shore of Saginaw Bay, Michigan.

Publications in Press. The publications in press include two volumes by Dr. Alfred C. Lane, constituting Publications 6, on the Keweenaw Series of Michigan, and Publication 8 on the Mineral Resources of the state, prepared under the supervision of the Director.

Mineral Statistics. The latter volume is the first of a series which will henceforth be issued annually in accordance with Act No. 7 of the Public Acts of 1911, which abolished the office of the Commissioner of Mineral Statistics and transferred the duties formerly devolving on this office to the Michigan Geological and Biological Survey. In this series of annual bulletins there will be published complete statistics of the production and value of the various mineral products of the state, together with a discussion of the progress and status of the mineral industry for the current years and new developments in geology having a bearing on the development of the mineral industry. The statistics of production are obtained directly from the producers under co-operative arrangement with the Division of Mineral Resources of the U. S. Geological Survey. Results are tabulated early in the year and preliminary statements issued to the press of the state and leading technical journals.

Publications in Preparation. There is completed and awaiting publication, (1) the geology of Arenac county, by Prof. W. M. Gregory; (2) the geology of Wayne county, by Prof. W. H. Sherzer, including chapters on the Dundee of southern Michigan, by Prof. A. W. Grabau, and

on the vegetation of the county by Forest B. H. Brown, and (3) a biological report on the amphibians and the reptiles of Michigan.

There is in course of preparation (4) a report upon the salt industry of Michigan by C. W. Cook, (5) a palaeontological report on the Dundee-Traverse formation by Prof. A. W. Grabau, and (6) a publication by Prof. Frank Leverett on the surface or soil formations of the Southern Peninsula.

New Laboratory and Fire Proof Vault. The facilities and equipment of the Survey have been very materially augmented by the installation of a chemical and petrographic laboratory now nearing completion. A new shipping room has also been provided by the Board of State Auditors. The addition of the laboratory and shipping room almost doubles the floor space now occupied by the Survey. A commodious fire-proof vault has been provided for the safe keeping of the original field notes and records, plats and drawings which could not be replaced if destroyed.

CO-OPERATION WITH THE UNIVERSITY.

Through a co-operative agreement with the University, by permission of the Board of Regents, Prof. Alfred H. White of the University and the Director have made arrangements for the testing of clays and the making of chemical analyses in the chemical laboratory at the University. It is not the intention to compete in any sense with private laboratories. The Survey does not maintain an analytical or testing laboratory, but has almost constant need for such equipment in execution of its investigations and also in rendering information in specific instances where same is applied for by citizens of the state. By this co-operation there is avoided duplication of equipment and expense. The Survey does not support a chemist and our new laboratory is equipped mainly for qualitative chemical analyses as an aid in the study of minerals, rocks and ores.

CO-OPERATION WITH PUBLIC DOMAIN COMMISSION.

Under the law all mineral values in state lands, including acreage hereafter acquired, shall remain the property of the state. The mineral values may, however, be leased for mining purposes and a number of applications for lease and option have already been received. The Director has gladly accepted the invitation of the Public Domain Commission to act as advisor in matters relative to the disposition of mining options and leases on state-owned lands.

NEW MEMBERS OF THE BOARD OF ADVISERS AND SURVEY STAFF.

The Board of Advisers comprises a limited number of the leading scientists of the state who are appointed from time to time, and who act without pay. The Director is much indebted to this body for aid and advice in matters affecting the interests of the Survey. Mr. Bryant Walker of Detroit, Prof. W. H. Sherzer of Ypsilanti, and Dr. Ernest Bessey of East Lansing have recently consented to act on the Board, the latter to fill the vacancy created by the removal from the State of Dr. W. J. Beal.

Mr. R. A. Smith was appointed Assistant Geologist to assume duties in October, 1911.

FIELD WORK, 1911-1912.

The field work on the upmapped Huronian area of the Northern Peninsula which began in the Iron River district in 1909, and was continued west of this district throughout the field seasons of 1910 and 1911, will be continued during the season of 1912. This work, though only partly completed, has already led to very important economic and scientific results. This work, together with that of the Wisconsin Geological Survey in the Florence district has corrected, and in fact largely revolutionized current ideas of the structure of the pre-Cambrian rocks south of the Menominee and Gogebic iron districts.

PROGRESS OF TOPOGRAPHIC WORK IN MICHIGAN.

Co-operation in topographic mapping with the United States Geological Survey was commenced by the State of Michigan in 1901, when an allotment for such work was made by the Director of the State Geological Survey. Since then the amount of co-operation has been as follows:

1903	$800
1905	2,000
1906	3,000
1907	3,000
1908	1,000
1909	2,000
1910	2,000
1911	2,000

The thirty-second annual report of the Director of the United States Geological Survey shows that 5,117 square miles have been topographically mapped in the State of Michigan up to June 30, 1911, this being about nine per cent of the entire area of the State. Of this area reported as mapped, 3,530 square miles are located in the southeastern part of the State. The resultant maps of this area, published on the scale of 1:62,500, were made under the topographic standards now in force in the Geological Survey and are in such detail as to satisfy the engineering and economic, as well as geologic, needs of this portion of the country.

Much of the area mapped in the northern peninsula is classified as reconnaissance on the maps of that country, with the exception of the Marquette, Calumet Special, and Menominee Special sheets.

Practically all of the quadrangles in the southern peninsula were surveyed through a co-operative arrangement between the Federal Survey and the State Geological Survey of Michigan, but the amount of such co-operation has been comparatively small on each side and only sufficient to complete about one quadrangle a year.

The wisdom of establishing cooperation with the United States Geological Survey for topographic mapping within the State has been fully demonstrated by the results obtained during the nine years in which it has been carried on. The popular interest shown in the progress of the work and in the data showing the completion of topographic surveys in certain sections is ample proof of the need of work of this class.

It is important that a much larger appropriation be made for co-operative work with the United States Geological Survey than has been available during the past few years. Topographic maps in the Upper Peninsula are most urgently needed for the study of the development of that entire portion of our commonwealth, and experience has shown that the cost of surveys in territory similar to this is relatively small

compared to the uses made of the resultant maps. The following are some of the uses which are made of topographic maps:

1. As preliminary maps for planning extensive irrigation and drainage projects, showing areas of catchment for water supply, sites for reservoirs, routes of canals, etc.

2. For laying out highways, electric roads, railroad, aqueducts, and sewage systems, thus saving the cost of preliminary surveys.

3. For improving rivers and smaller waterways.

4. In determining and classifying water resources, both surface and underground.

5. In the problem of the most feasible and economical selection of water supply for cities.

6. In making plans for the disposal of city sewage, garbage, etc.

7. In determining routes, mileage, location of road-building material, and topography in country traversed by public highways.

8. In selecting the best routes for automobiling tours and intercity runs.

9. As guide maps for prospectors and others in traveling through little known regions.

10. As bases for the compilation of maps showing the extent and character of forest and grazing lands.

11. In classifying lands and in plotting the distribution and nature of the soils.

12. In compiling maps in connection with the survey and sale of lands.

13. In making investigations for the improvement of the plant and animal industries, and in a comprehensive study of physical and biological conditions in connection with the stocking of interior waters with good fishes and the locating of fish culture stations.

14. In locating and mapping the boundaries of life and crop zones, and in mapping the geographic distribution of plants and animals.

15. In plotting the distribution and spread of injurious insects and germs.

16. As a base map for the plotting of information relating to the geology and mineral resources of the country.

17. In maneuvers of the national guard, in the development of military problems and in the selection of routes for road marches or strategical movements of the troops, particularly of artillery or cavalry.

18. In connection with questions relating to state, county, and town boundaries.

19. As a means of promoting an exact knowledge of the country and serving teachers and pupils in geographic studies.

20. As base maps for the graphic representation of all facts relating to population, industries, and products or other statistical information.

21. In connection with legislation involving the granting of charters, rights, etc., when a physical knowledge of the country may be desirable or necessary.

In comparison with the neighboring State of Ohio, the amounts allotted to co-operation heretofore seem insignificant indeed, and the results of the liberal policy in Ohio are apparent when one realizes that the entire area of the State will be covered by modern topographic maps

within the next four or five years, and that more than seventy per cent of the State has been completed already.

In addition to the co-operative work, the United States Geological Survey has completed a map on the field scale of 1:24,000 in the vicinity of Calumet, and has extended both vertical and horizontal control across the Upper Peninsula in such a manner as to make it possible to inaugurate new work without extensive control surveys having to be brought into the country before such specific work can begin.

REPORT OF TOPOGRAPHIC SURVEYS IN CO-OPERATION BETWEEN THE UNITED STATES GEOLOGICAL SURVEY AND THE STATE OF MICHIGAN FOR THE PERIOD BEGINNING JULY 1, 1910, AND ENDING DECEMBER 31, 1911.

In accordance with the co-operative agreements signed June 25, 1910, and May 23, 1911, by George Otis Smith, Director, for the United States Geological Survey, and by R. C. Allen, State Geologist, June 30, 1910, and May 31, 1911, for the State of Michigan, the Federal Survey each year allotted $2,000 and the State, $2,000, for co-operative topographic surveys in the State of Michigan during the fiscal years July 1, 1910, to June 30, 1912.

The following is a summary of the field and office work accomplished during the period from July 1, 1910, to December 31, 1911, under the general direction of R. B. Marshall, Chief Geographer, and under the immediate supervision of W. H. Herron, Geographer of the Central Division.

FIELD WORK.

During period from July 1, 1910, to Dec. 31, 1911.

Quadrangles.	Counties.	For publication on scale of.	Area mapped sq. mi.	Primary levels.		Traverse		
				Miles.	Perm. B. M.'s.	Primary. Miles.	Primary. P. marks	Miles.
Lansing	Ingham and Eaton	1:62,500	166					
Alvordton	Hillsdale and Lenawee	1:62,500	39	17	7			95
Grand Rapids	Kent and Allegan	1:62,500	27	122	24	66	9	74
Montpelier	Hillsdale	1:62,500	45					170
Swanton	Monroe and Lenawee	1:62,500	26	15	3			
Wauseon	Lenawee	1:62,500	33	13	5			96
Adrian	Lenawee	1:62,500				13	2	
Allegan	Allegan	1:62,500				10	1	
Blissfield	Lenawee					19	2	
Centerville	St. Joseph					8	1	
Cedar Springs	Kent					8	1	
Charlotte	Eaton					8	1	
Gobleville	Kalamazoo					8	1	
Hastings	Barry			12	3	8	1	
Hillsdale	Hillsdale and Lenawee					16	2	
Hudson	Hillsdale and Lenawee					19	2	
Holland	Ottawa and Allegan			11	4			
Ionia	Barry			10	4	8	1	
Jenison	Kent			11	4	9	2	
Jones	St. Joseph and Cass					9	1	
Kalamazoo	Kalamazoo and Allegan					9	1	
Lowell	Barry, Kent and Ionia			5	2	18	1	
Muir	Ionia, Eaton and Clinton			9	2	8	1	
Marcellus	Kalamazoo					11	1	
Reading	Hillsdale and Branch					2	1	
Schoolcraft	Kalamazoo and St. Joseph					12	1	
Vermontville	Barry and Eaton			5	2	8	1	
Wayland	Allegan					9	1	
Total			336	230	60	286	35	435

The following members of the United States Geological Survey were engaged in the field work:

Topographic Mapping:

J. H. Jennings, Geographer.
A. M. Walker, Topographic Engineer.
L. L. Lee, Assistant Topographer.
Fred Graff, Jr., Assistant Topographer.
H. W. Peabody, Assistant Topographer.
L. D. Townsend, Junior Topographer.
N. E. Ballmer, Junior Topographer.
C. R. French, Junior Topographer.
C. W. Howell, Topographic Aid.

Primary Traverse:

J. R. Ellis, Topographer.
J. H. Wilson, Junior Topographer.

Levels:

L. D. Townsend, Junior Topographer.
J. J. McNulta, Topographic Aid.
F. J. Mabrey, Topographic Aid.
C. E. Mills, Topographic Aid.

OFFICE WORK.

The office drafting of the Lansing sheet was completed and transmitted for engraving, April 4, 1911. The drafting of the Grand Rapids sheet was commenced, twelve per cent being completed December 31, 1911.

The adjustment of the levels for the Grand Rapids quadrangle, furnishing complete vertical control, has been made and the field notes typewritten and prepared for publication. Partial vertical control for the Holland, Ionia, Jenison, Lowell, and Muir area has been adjusted and the results typewritten and prepared for publication.

The final computations for the geographic positions furnishing complete control for the Swanton quadrangle have been made and the results typewritten and prepared for publication. Preliminary computations for the geographic positions in the Grand Rapids area have been made. Partial horizontal control for the Adrian, Alvordton, Blissfield, Hillsdale, Hudson, and Reading quadrangles has been furnished by the computation of geographic positions, which results have been prepared for publication. A preliminary adjustment of the traverse line furnishing partial horizontal control for the Allegan, Cedar Springs, Centerville, Charlotte, Gobleville, Hastings, Ionia, Jenison, Jones, Kalamazoo, Lowell, Marcellus, Muir, Schoolcraft, Vermontville, and Wayland quadrangles has been made, but final adjustment not yet completed.

REPORT OF THE CHIEF NATURALIST.[1]

BY ALEXANDER G. RUTHVEN.

Mr. President and Members of the Academy:

The biological work carried on by the survey since the last report to the Academy may be divided into field work, the preparation of manuscripts, and the publication of reports and papers.

During the field season of 1911, we had six persons in the field for various periods of time. It seemed advisable to finish the Charity Island work of 1910, so that the other work was necessarily scattered, as our funds are far too small to permit us to send men to several localities for more than a short time, unless we choose places, where, for one reason or another, particular persons can work cheaply.

Mr. F. C. Gates investigated the flora of the Douglas Lake region. He spent five weeks in the field, and secured about 1,500 specimens, representing nearly 500 species, and a large amount of notes.

Mr. Orrin J. Wenzel studied the mammals of Osceola County in August and September, greatly increasing our knowledge of the fauna both by notes and specimens.

Mr. N. A. Wood was sent to the Charity Islands, Lake Huron, to study the resident birds, thus supplementing the work of the Mershon Expedition of last year. He spent four weeks on the islands in July and obtained the material for an extensive report. The Chief Naturalist visited the Charity Islands in July to complete the work on the reptiles and amphibians, and Miss Crystal Thompson and Miss Helen Thompson were sent over from Port Austin in August to make a set of photographs of the habitats, to be used in the reports.

The manuscripts in preparation are from two sources. Some are the results of field work done for the survey, and others have been prepared independently and submitted to us for publication. We have completed and awaiting publication the following reports:

Crystal Thompson and Helen Thompson on the amphibians of Michigan; A. G. Ruthven and Frances Dunbar on the reptiles of the state; F. C. Gates on the flora of the Douglas Lake region; O. J. Wenzel on the mammals of Osceola County; N. A. Wood on the breeding birds of the Charity Islands; Crystal Thompson and Helen Thompson on the amphibians and reptiles of the Charity Islands; C. K. Dodge on the plants of Lambton County, Ontario; Harlan I. Smith on a bibliography of Michigan archaeology, and W. W. Newcomb on a checklist of Michigan butterflies.

During the coming year we will also have completed A. W. Andrews' exhaustive report on the Coleoptera of Charity Island, the report by C. H. Kauffman and L. H. Pennington on the botanical studies in southeastern Michigan in 1910, C. H. Kauffman's monograph on the

[1]Read at the general session of the Michigan Academy of Science, March 27, 1912.

Agaracaceae, and Bryant Walker's "Synopsis of the Classification of the Fresh Water Mollusca."

Other papers in progress are, an annotated list of the beetles of Wayne County by A. W. Andrews, the reports on the investigations in Dickinson County in 1909, a report upon the flora of the east coast of Michigan by C. K. Dodge, a catalog of the mammals of the state by N. A. Wood, a synopsis of the larvae of Michigan amphibians by Helen Thompson, reports upon the Mallophaga of the various surveys, by Charles A. Shull and E. P. Durrant, a synopsis of Michigan fish by Crystal Thompson, and a checklist of Michigan moths by W. W. Newcomb.

The publications since the last report to the Academy are as follows:

A Biological Survey of the Sand Dune Region on the South Shore of Saginaw Bay, Michigan. Michigan Geological and Biological Survey, Pub. 4, Biol. Ser. 2, 347 pages, 19 plates, 1 map.

The Results of the Mershon Expedition to the Charity Islands, Lake Huron:

Birds, by N. A. Wood, Wilson Bulletin, June, 1911, pp. 78-112, 1 map.

Plants, by C. K. Dodge, 13th. Ann. Rept. Mich. Acad. Sci., 1911, pp. 173-190.

Mammals, by N. A. Wood, ibid., pp. 131-134.

Preliminary Report on the Coleoptera, by A. W. Andrews, ibid., pp. 168-170.

Notes on Michigan Crustacea, I, by A. S. Pearse, 13th. Ann. Rept. Mich. Acad. Sci., 1911, p. 130.

Notes on Michigan Reptiles and Amphibians, III, by Alexander G. Ruthven, 13th Ann. Rept., Mich. Acad. Sci., 1911, pp. 114-115, 1 plate.

The board of advisors have approved the following plans for field work next summer: Mr. C. K. Dodge will continue his studies on the flora of the east coast by investigating the region north of Saginaw Bay, and a preliminary investigation of the fauna of Chippewa County will be made under the direction of the Chief Naturalist. The work in Chippewa County will be done in conjunction with the University of Michigan Museum, as Hon. George Shiras, Washington, D. C., has given to the museum the funds necessary to send a man into the region for a part of the summer.

It will not be out of place here to refer to the advantages to the survey that result from its present connection with the University of Michigan Museum and the Michigan Agricultural College. The survey has made the museum the repository of its zoological collections, thus freeing itself from the expense and work attached to the preservation of the material. At the same time the Chief Naturalist, as Head Curator of the Museum, feels that he is increasing the efficiency of the museum work by making it supplement the investigations of the survey. This assists the survey by increasing the work accomplished, and by placing at its disposal the miscellaneous material obtained by the museum. At the January meeting of the Board of Advisors the Michigan Agricultural College was made the repository of the botanical collections of the survey, and this ought to bring about co-operation between these institutions that will be equally advantageous to each one.

In view of the limited facilities for natural history work in the state

we cannot over-estimate the advantages of such co-operation. None of the institutions interested in the work have the means of carrying it on extensively, but by uniting much can be accomplished, better results obtained, and needless duplication of work avoided.

I append a map showing the counties in which detailed biological surveys have been carried on, either by the survey or the museum. It should be explained that in no case have the investigations covered an entire county or included more than a few groups.

A "CLEARING HOUSE" FOR REPORTS ON FUNGUS DISTRIBUTION.

BY ERNST A. BESSEY.

(Abstract.)

Many fungi are picked up by botanists and examined, only to be laid aside when they are determined to be species already described or when the special purpose for which they were collected is accomplished. In the vast majority of such cases no published record is made of the occurrence of these fungi. Thus it happens that the exsiccati and the large herbaria throughout the country very often are very deficient as regards completeness even for some of the commoner species. The poor monographer who has to rely upon published reports and specimens preserved in the various herbaria is not to be blamed when he omits from this country species that are quite common but which have not had the luck to have been collected for distribution or to have appeared in state or local lists.

It is suggested that a "clearing house" for reports of the occurrence of fungi be established, in connection with some mycological journal. To this place would be reported all such finds of fungi together with records of place where the specimens are preserved. These lists should be published monthly giving name of fungus, name of persons collecting and determining the species, date, locality, substratum and number under which the specimen is filed in some herbarium, preferably some large, easily accessible one. Thus, even if the determination should prove incorrect, it would be possible for a student of the group to have access to the specimen and determine the point before publishing the name in a monograph.

A name should not be allowed to appear more than once or twice from a region (or state) unless on new hosts. Thus there would be requisite the services of an editor for the list who would also make all names conform to some recognized nomenclatorial system. Perhaps no names should be published except those lacking in regional or state lists for the locality where the reported fungus was found. Otherwise the editor would be swamped with reports of very common species from states that have not yet published lists.

DEMONSTRATIONS OF ECTOTROPHIC AND ENDOTROPHIC MYCORHIZA.

(Abstract.)

W. B. McDOUGALL.

The study of the mycorhiza of our common forest trees was begun, by the author, in July, 1911. The purpose, primarily, was to work out the seasonal relations of these mycorhiza, and, if possible, to add something to our knowledge of their physiological and ecological relations. The work will continue another year before anything like a complete report can be given. It seems desirable, however, to call attention, at the present time, to the following results.

1. On *Caryo ovata* three forms of ectotrophic mycorhiza, distinguishable by their external color, and also by their microscopic structure, have been found on the same tree. One of these is bright yellow in color. The fungus mantle is distinctly filamentous, and numerous short branches extend from it into the soil. A second form is brown. The fungus mantle in this case consists of pseudoparenchyma such as is found in many lichens. The outer surface is smooth, without any outward extending branches. A third form, found on Carya, is whitish or nearly colorless. The fungus mantle is distinctly filamentous, but is smooth on the outside.

2. On Quercus the same variations in microscopic structure were found, but without the variations in color, all specimens collected being whitish.

3. On Larix laricina a form was found in which the outer cells of the root cortex are so pushed apart by the growth of mycelia between them that some of them are isolated as islands in the fungus mantle.

4. On Acer saccharinum and Acer rubrum endotrophic mycorhiza were found in great abundance. The vesicles described by several authors were frequently found in the mycorhiza of the maples.

5. On Tilia americana specimens were collected in which one and the same fungus is both ectotrophic and endotrophic. This novel form is hitherto unreported, and may be classified as a heterotrophic mycorhiza.

(Lantern slides and microscopic slides of all forms mentioned were shown.)

THE VEGETATION OF THE REGION IN THE VICINITY OF DOUGLAS LAKE, CHEBOYGAN COUNTY, MICHIGAN, 1911[1]

BY FRANK C. GATES.

INTRODUCTION.

While engaged in the field operations of the Michigan Geological and Biological Survey during the summer of 1911, the author was stationed at the University of Michigan Biological Station at Douglas Lake from June 20th to August 21st. A nearly complete representation of the higher plants was collected and deposited with the Survey. Many notes and fotografs were taken which serve as the basis of this report.

LOCATION AND GENERAL DESCRIPTION OF THE REGION.

Douglas Lake is located in the northern end of the Southern Peninsula, midway between Lake Huron and Lake Michigan and about 17 miles south of Mackinaw City, at an elevation of 710 feet above sea level or 130 feet above Lake Michigan. While the special features of the region are indicated on the accompanying map (Plate 1), in general, the region is a level, sandy pinery with a few ridges and hills of morainic origin. Two fair-sized lakes, Douglas Lake and Burt Lake, are about two miles apart, but Douglas Lake is 118 feet higher than Burt Lake. A general view of Burt Lake is shown in Plate 5. A few rather insignificant streams flow into Douglas Lake and the lake itself flows into Burt Lake thru a small stream, known as Maple River, shown in Plate 6a. Its channel is, however, not open for boats. The greater part of the drainage of such soil is underground. Sometimes very definite channels are formed, of which the most evident are those coming to the surface about two-thirds of a mile southwest of the university station, at the head of a gorge. They form the little stream, Carp Creek, which drains into Burt Lake. The gorge is continually being cut further back and should it be cut a mile more towards the north, Douglas Lake would be nearly drained. These lakes have sandy shores which extend down into the water as a shallow shelf, usually a number of feet wide and deepening with a gradual slope. This shelf is terminated by a sudden, precipitous drop, known as the "drop-off," beyond which it may be 20 to 65 or 80 feet to the bottom. The drop-off is exceedingly well-markt by the sudden change of color of the shallow water to the deep blue of the deep water. When aquatic vegetation is present there are no emerst plants beyond the drop-off.

Thruout the rest of the region, with the exception of the streams and occasional marshes and *Chamaedaphne* bogs, the tree form of vegetation prevails. The aspen type is most widely distributed, tho its members

[1]Published by permission of Alexander G. Ruthven, Chief Naturalist, Michigan Geological and Biological Survey.

are smallest in size. The bog type stands next both in distribution and size, while the hardwood, altho largest in size is least widely distributed. No pine stands remain as such at the present time.

CLIMATE.

There are no weather bureau stations in the immediate vicinity, but those at St. Ignace, Charlevoix and Cheboygan, Michigan, will give an idea of the meteorology. The data is exprest grafically in Plates 3 and 4. The region lies between these stations, but the weather conditions are probably more nearly like those of Cheboygan than of the other stations.

The climatic factors act in a broad way, and altho the vegetation is an expression of the integration of climatic and edaphic factors it does not always appear so, as the factors are measured at the present time. In general the winters are long, persistently cold, with quite a little snow. During the summer the days are hot, while the nights are cool. Precipitation is more than sufficient to support tree growth. It is most abundant during winter and spring. The long dry period during the summer and fall, altho not in itself very seriously interfering with the development of the trees, assumes considerable importance in paving the way for fire—the bane of the development of the region.

THE VEGETATIONAL HISTORY OF THE REGION.

The region has been glaciated repeatedly. The present surface drift is largely sand. With the retreat of the glaciers, vegetation appeared and developt to a temporary climax for the soil types. The better uplands were covered by the hardwood forest of beech, sugar maple, and hemlock which graded into pine on the poorer soils. The greater part of the pine land was occupied by *Pinus resinosa* (Norway Pine) and *Pinus strobus* (White Pine), but the worst land was originally covered with *Pinus banksiana*. The moist lowlands were cedar bogs. There were no signs of prairie vegetation.

Then came the period of the lumberman and with him fire. Without exception the pine land was cut clear and if, perchance, any part escapt cutting the fire took it. With only a few exceptions the hardwoods also were cut and the cut-over land burnt. A few areas, however, which were not cut, give an idea of their former appearance. For the most part the cedar bogs were cut over but usually they were not so damaged by fire.

The immediate result of the clearing was the installation of a new vegetation cycle. Fireweeds sprang up in abundance but their dominance on a given area seldom lasted more than a year or two. *Epilobium angustifolium* and *Erechtites hieracifolius* were the most abundant fire weeds. Climatic conditions were entirely suitable for trees and trees appeared—but very few in the first year, but increasing in numbers in the following years. For the most part these trees were aspens (*Populus tremuloides* in the moister soil and *Populus grandidentata* in the drier land), birch (*Betula alba papyrifera*) and pin or fire cherry (*Prunus pennsylvanica*). The vegetation of the forest floor consisted of an abundance of *Pteris aquilina*, *Diervilla lonicera* and such plants as withstood the fire and remained as relics of the previous association.

On pine land such as association persisted for a number of years, altho ultimately it would be replaced by other associations. Where this has not already happened, frequent fires are the cause, for they easily kill the small seedlings. As pine must be reestablisht by seeds, this very materially increases the time from pine to pine as each fire depletes the soil in addition to killing the seeds, seedlings and seeding trees.

Normally aspen dominance of hardwood land was much shorter, both because the hardwoods seed easier and sprouts from the stumps often obviate seeding entirely. This results in vegetation of a mixtur of hardwoods and aspens, with occasionally more or less pine. Ultimately, however, if the soil is favorable, the entire stand will be hardwood.

On bog land aspen dominance was very seldom attained, because ecesis of the bog trees was easy and they could much more than hold their own against aspens. After a burn in the cedar bog, revegetation was very largely by tamarack (*Larix laricina*), altho this tree is but sparingly represented in a typical cedar bog. The tamarack grows readily and forms a dense stand which may reach a hight of about 55 feet. Soon, however, cedar (*Thuja occidentalis*) and spruce (*Picea mariana*) appeared and developt rapidly. From a distance such bogs appear to be pure tamarack, until either the tamarack dies naturally, or is killed by the larvae of the sawfly, or is overtopt by the spruce and cedar. The cedar bog is the climatic type on boggy soil.

THE VEGETATION.

As vegetation is seldom in a static condition, the treatment of the plant associations according to their arrangement in the developmental or genetic series is the most logical. This method does not signify that every given spot of bare ground becomes vegetated by the lowest members of its normal genetic series and the succession continues until the climatic type for the region becomes prevalent. In a normal genetic series such would be the case. Expressing series of fenomena in this manner leads to a clearer insight over the whole field and to a clearer explanation of apparent exceptions. A genetic series begins with the lower types of vegetation and proceeds progressively to higher types. A complete series would be the one in which every step was taken, but this is frequently not the case. Sometimes steps may be omitted and certain steps may take very much longer than others. In spite of these facts, the general trend of the vegetation is from the lower steps of the genetic series to the higher and the varying environmental factors and accidents are largely responsible for the actual steps.

In this region there are five distinct genetic series. Of these, four are primary series, that is, the natural series that represent the vegetational dynamics without the interference of man, and one, the burn series, for which man is directly responsible. The primary series may be designated: (1) the lake series, whose associations progress from deeper water up to the land; (2) the swamp series, whose associations in this region replace open water with swamp vegetation (of relatively minor importance in this region); (3) the bog series, whose associations convert open water into a tree-covered tract; and (4) the sandy-land series, whose associations lead towards the development of hardwood forest. Any one of these series may run into some of the others.

THE ASSOCIATIONS IN UNBURNT AREAS.

The Plankton Association.

The free swimming and floating algae and protozoans which constitute the plankton were not investigated.

The Chara Association.

This association of submerged rooted aquatics is the first in the lake series of genetic succession. It occurs normally in the deeper water of the various lakes in the region. It may be obtained by dredging or by collecting the plants which are uprooted and washt ashore during storms.

On account of the extreme openness of the aquatic vegetation in these lakes, *Chara* also grows in shallow water—almost up to the shore line in certain bays where there is no higher vegetation to prevent its development. For this reason, also, *Chara* exists as a relic in every aquatic association. With the *Chara, Myriophyllum spicatum* and *Elodea canadensis* may be frequently associated as secondary species.

The Potamogeton Association.

This association of submerged, rooted aquatics develops in shallower water than *Chara* normally does, but it can not grow in as shallow water as *Chara* will under favorable conditions. As this association is usually developt in Douglas Lake, fairly dense patches of vegetation are strung along the drop-off, extending shoreward until the water is somewhat over a foot in depth, unless stopt by other vegetation. This association is partial to the sheltered bays and exists only in small isolated patches in the open lake, where it is subject to severe wave action. This is shown in Plate 6b. On account of the openness of the aquatic vegetation that is prevalent in this region, the species of this association readily remain as relics in the succeeding associations.

List of the Species of the Potamogeton Association:

DOMINANT SPECIES.

Potamogeton natans.
Potamogeton richardsonianus.
Potamogeton zosterifolius.
Potamogeton pectinatus.
Potamogeton heterophyllus.
forms *myriophyllus* and *maximus.*
Potamogeton filiformis.
Potamogeton lucens.
Potamogeton strictifolius.
Naias flexilis.
Ceratophyllum demersum.

SECONDARY SPECIES.

Elodea canadensis.
Vallisneria spiralis.
Myriophyllum spicatum.

RELIC SPECIES.

Chara spp.

INVADING SPECIES.

Nymphaea americana.

The Castalia-Nymphaea Association.

This association of rooted aquatics with floating leaves and flowers occurs sparingly in the lakes of the region. In the ponds and smaller lakes, where the water is quiet, *Nymphaea americana* and *Castalia odorata* form their typical zone. In Douglas Lake this association occurs only in protected bays, where it is represented by *Nymphaea americana* growing in water two to four feet in depth. The association is very open and seedling plants are usually abundant, suggesting reproduction by seeds rather than growth of the rootstocks. A number of the rootstocks are undoubtedly uprooted by the ice during the winter. The stems catch more or less of the uprooted and floating *Chara, Elodea, Potamogeton* and *Myriophyllum*—some of which, particularly *Myriophyllum* and *Elodea*, frequently take root and develop as secondary species.

In the larger lakes this association is succeeded by the *Scirpus validus* association, or on very shallow shores by the *Eleocharis palustris vigens* association. In boggy situations and in the very small lakes, such associations as the *Typha*, the *Carex filiformis*, the *Menyanthes-Sagittaria* or the *Chamaedaphne* associations may displace this association, depending upon the distribution of seeds or the presence of the plants of these associations in the immediate vicinity.

List of the Species of the *Castalia-Nymphaea* Association:

DOMINANT SPECIES.

Castalia odorata.
Castalia tuberosa.
Nymphaea americana.

SECONDARY SPECIES.

Elodea canadensis.
Vallisneria spiralis.
Myriophyllum spicatum.

RELIC SPECIES.

Potamogeton natans.

INVADING SPECIES.

Scirpus validus.
Eleocharis palustris vigens.

The Menyanthes-Sagittaria Association.

This association of aquatic plants is represented very sparingly in the region of Bessey Creek, a bog southeast of Douglas Lake and along parts of the little streams running thru some of the cedar bogs. As a rule it is represented by *Sagittaria latifolia*, with quite narrow leaves. Less frequently *the Sagittaria* is accompanied by *Menyanthes*. Only in Bessey Creek did *Sparganium simplex* occur with it. *Sparganium* grew out into deeper water than *Sagittaria* was observed but in

shallower water than that in which the *Potamogetons* occurred. With them it maintains a sharp tension line. Secondary species are seldom present in this region.

This is a pioneer association in the open water in some of the creeks of the region, but where it is competing with other associations, it normally follows the *Castalia-Nymphaea* association. It may give place to any one of several associations. In creeks, the *Eleocharis* association is more often the succeeding one but near the mouth of Bessey Creek it gives place to *Scirpus validus*. This occurs only on the side towards the shore, as the *Menyanthes-Sagittaria* association can not exist in water subject to wave action. *Sagittaria* can not grow in water as deep as *Scirpus validus* is able to, yet when these two come into competition on ground that does not preclude the *Sagittaria*, it occupies a lower position in the genetic scale than *Scirpus validus*. In treeless bogs this association is succeeded by *Carex filiformis* or by *Chamaedaphne calyculata*. One instance of succession to *Phragmites-Typha* was observed in a bog southeast of Douglas Lake. When occurring along the creeks in cedar bogs, it is usually separated from the *Thuja* by the *Iris* association.

List of the Species of the Menyanthes-Sagittaria Association:

DOMINANT SPECIES.

Sagittaria latifolia.
Menyanthes trifoliata.
Sparganium simplex.

SECONDARY SPECIES.

Mentha arvensis canadensis.
Mimulus glabratus jamesii.

RELIC SPECIES.

Castalia odorata.

INVADING SPECIES.

Eleocharis palustris vigens.
Scirpus validus.
Carex filiformis.
Chamaedaphne calyculata.
Typha latifolia.
Iris versicolor.

The Eleocharis Association.

In some of the sheltered bays where the slope of the bottom was very gentle this association of water plants was occasionally present. The water there was less than a foot in depth and the association extended out of water. The dominant species was *Eleocharis palustris vigens*, a plant which spreads very rapidly by underground rootstocks and takes nearly complete control of the ground once it obtains a start. The secondary species were not numerous and only occasionally conspicuous.

As a rule, this association seemed to be the end of this genetic series, for between it and the land plants there was usually an open stretch of water in addition to the lower beach which was usually plantless. In a few of the long spits which project out into the waters of North Fishtail Bay succession to the *Scirpus americanus* association was clear-

ly indicated by the gradual grading of the *Eleocharis* into the *Scirpus americanus* as the water became shallower.

List of the Species of the Eleocharis Association:

DOMINANT SPECIES.

Eleocharis palustris vigens.

SECONDARY SPECIES.

Utricularia cornuta.
Glyceria borealis.
Veronica anagallis-aquatica.
Oxypolis rigidior.

RELIC SPECIES.

Nymphaea americana.
Sagittaria latifolia.

INVADING SPECIES.

Lycopus americanus.
Solidago graminifolia.
Scirpus americanus.
Iris versicolor.
Spartina michauxiana.
Lobelia cardinalis.
Mentha arvensis canadensis.
Mimulus ringens.
Potentilla palustris.
Acer rubrum (seedlings).
Cornus stolonifera (seedlings).
Salix lucida (seedlings).

The Scirpus validus Association.

This association of aquatic plants, rooted below the surface of the water but extending above the water, appears to be the most extensively represented aquatic association, altho the *Chara* association really is so. It occupies submerged land from water level down to water about 8 feet in depth. In Douglas Lake it is limited to the shoals and the shores of bays and inlets, especially towards the west where the lake is more protected from the prevailing winds. Except at the mouth of Bessey Creek, this association occurs in patches which are not very dense, and yet there are virtually no secondary species. At the mouth of Bessey Creek is a very dense growth of this association, shown in Plate 7a. In places in it, the way has been paved for a considerably higher association in the genetic series and such plants as *Decodon verticillatus*, *Eupatorium perfoliatum*, *Eupatorium purpureum*, *Lobelia cardinalis*, *Asclepias incarnata*, *Salix lucida* and *Sagittaria latifolia* are now present.

Normally this association is succeeded by the *Scirpus americanus* association, but during 1911, in the unusually high stages, following the heavy spring rains, the *Scirpus validus* association gave decided evidence of invading the *Scirpus americanus association*, in which the *Scirpus validus* is usually present as a relic. The extreme openness of the aquatic vegetation materially aided this invasion, which is a reversal of the normal line of succession.

List of the Species of the Scirpus validus Association.

DOMINANT SPECIES.

Scirpus validus.

SECONDARY SPECIES.

Myriophyllum spicatum.
Chara spp.
Elodea canadensis.

RELIC SPECIES.

Nymphaea americana (sparingly).
Scirpus americanus (in reversal of successions caused by higher water).

INVADING SPECIES.

Scirpus americanus.

(The following are of very local occurrence as noted above.)

Decodon verticillatus.
Eupatorium perfoliatum.
Eupatorium purpureum.
Lobelia cardinalis.
Asclepias incarnata.
Salix lucida.
Sagittaria latifolia.
Glyceria borealis.

The Scirpus americanus Association.

Extending from shallow water up on to the beach occurs the association dominated by the rush *Scirpus americanus.* It is fairly well represented in the protected bays of Douglas Lake. On the lakeward side it is usually bordered by either *Eleocharis palustris rigens* or *Scirpus validus*, but occasionally by open water. Landwards it extends up out of the water as far as the sand is moist clear to the surface. Relic plants, whose stems are very often spirally twisted, may persist for a while higher up on the beach. *Scirpus americanus* does not have a very wide range of water depth, as the season of 1911 shows. The heavy rains of the spring raised the level of the lake about two feet. The dry spell commenced in June but the water had not receded to its natural level until long in August. Many of the patches of *Scirpus americanus* were killed. The dead plants turned jet black and were probably suffocated on account of lack of air. The depth of water over these killed patches was not more than eight inches during August but only very rarely was there sufficient life left to send up a stalk, altho further in towards the land there was the normal growth of this plant. *Scirpus validus* began to come in rapidly and by the end of August had recaptured a few of the *Scirpus americanus* areas.

On the landward side, evidences of a true genetic succession are not conspicuous. The edaphic conditions are changed rather suddenly as is also the change in the plant life. Very frequently there is an open strip of sand between the *Scirpus americanus* and the land vegetation. On the low, level, sandy spits, where the slope is hardly perceptible, evidences of the relationship of the land and water associations appear. As a rule it is the *Potentilla anserina* association that comes into the

Scirpus americanus but the numerous seedlings of red maple and willows give evidence of how rapidly a bog could be formed if it were not for the wave action during the summer and the far more serious ice work during the winter.

List of the Species of the Scirpus americanus Association:

DOMINANT SPECIES.

Scirpus americanus.

SECONDARY SPECIES.

Utricularia cornuta.
Elodea canadensis.
Oxypolis rigidior.

RELIC SPECIES.

Scirpus validus.
Eleocharis palustris vigens.
Potamogeton richardsonii.

INVADING SPECIES.

Scirpus validus (in reversal of successions).
Lycopus americanus.
Solidago graminifolia.
Iris versicolor.
Spartina michauxiana.
Acer rubrum (seedlings).
Cornus stolonifera (seedlings).
Salix lucida (seedlings).
Juncus balticus littoralis.
Eupatorium perfoliatum.
Alnus incana.
Lysimachia terrestris.
Salix longifolia.
Potentilla anserina.
Hypericum virginicum.
Cladium mariscoides.

The Cladium mariscoides Association.

This association of rush-like plants, entirely dominated by *Cladium mariscoides*, was very poorly represented in this region. It occurred along the west shore of Douglas Lake at the edge of a cedar bog. It was also present in a few other places where bogs were in the initial stages of their development. Everywhere it presented the same appearance—a dense growth of the rush with a very few secondary species towards the margins.

List of the Species of the Cladium mariscoides Association:

DOMINANT SPECIES.

Cladium mariscoides.

SECONDARY SPECIES.

Potentilla palustris.
Lobelia cardinalis.
Hypericum virginicum.
Asclepias incarnata.
Dulichium arundinaceum.
Carex oederi pumila.

RELIC SPECIES.

Scirpus validus.

INVADING SPECIES.

Iris versicolor.	*Lysimachia terrestris.*
Potentilla anserina.	*Campanula uliginosa.*
Eupatorium perfoliatum.	*Campanula aparinoides.*

The Juncus balticus littoralis Association.

This association of the lake beaches is represented in the region very scantily, on a few of the tungs of sand which projected out into South Fishtail bay, by a sprinkling of plants of the dominant species *Juncus balticus littoralis.* As a general thing, the *Juncus* is between the *Scirpus americanus* and the *Potentilla anserina*, showing succession into the former and giving way to the latter. Occasionally, however, on a very few of the stations there is no other vegetation between it and the open water. The severe ice work along the shore each winter is undoubtedly a potent factor in reducing the extent of this association in this region, for otherwise, conditions seem entirely suitable for it.

The Potentilla anserina Association.

This association of lowland plants, which in some localities quite extensively covers the beach, is extremely poorly represented in the region. In a few places a mere fringe of the dominant species at the foot of the fringing dune or ice-work bluff is all that there is to indicate the presence of this association of plants. In a few other places where the beach is very gently sloping and protected from severe wave action, the presence of a number of these plants mixt in with *Scirpus americanus* and *Eleocharis palustris vigens* indicates the presence of the association in the midst of rapid successions. Here the *Potentilla* grows from the water level up as far as other plants will permit it to grow. Submergence, however, cannot be withstood. In certain places, where this association develops around beach pools it serves to catch the seeds of bog trees, as *Acer rubrum* and *Thuja occidentalis.* In other places grasses, *Elymus canadenis* and *Spartina michauxiana,* obtain a start and a low dune may be formed.

List of the Species of the Potentilla anserina Association:

DOMINANT SPECIES.

Potentilla anserina.

SECONDARY SPECIES.

Solidago graminifolia.

RELIC SPECIES.

Scirpus americanus.	*Juncus balticus littoralis.*
Eleocharis palustris vigens.	

INVADING SPECIES.

Acer rubrum (seedlings).	*Elymus canadensis.*
Thuja occidentalis (seedlings).	*Spartina michauxiana.*

The Phragmites-Typha Association.

This asociation of swamp plants occupies an extremely limited part of the region. It is evidently a secondary development, following the clearing of bogs, which were too wet to cultivate successfully. The duration of this association, under present climatic conditions, provided the ground is undisturbed, could not be long because before the *Typha* is able to establish a closed association, which very nearly prohibits succession, the rapid ecesis of shrubs, particularly willows, but even tamarack and cedar, will have destroyed the identity of the association. Consequently the presence of this association is indicated by the presence of *Typha latifolia*, *Oxypolis rigidior* and a very little *Phragmites communis* as relic species in some of the willow thickets, which at the present time occupy wet, cleared places. Ultimately the bog forest cover will prevail.

As an association it is better represented in one of the treeless bogs northeast of Burt Lake. There a narrow belt of typically developt *Typha latifolia* separates either the *Castalia-Nymphaea* or the *Scirpus validus* from the *Carex filiformis* association. It is not unlikely that here the *Typha* invaded the tension line subsequent to the development of the *Carex* mat and the water lilies.

The Carex filiformis Association.

At the edge of the *Castalia-Nymphaea* or of the *Phragmites-Typha* or of the *Scirpus validus* associations or occasionally at the edge of the open water occurs the *Carex filiformis* association, one of the most typical of bog associations in this part of America. The dominant species, growing in great luxuriance, forms large mats of vegetation projecting out from the shore. The long, slender leaves wave loosely in the wind. At a distance the upper surface appears perfectly level. There are virtually no other plants present in this sedge growth, except at the tension lines on either side. Under the mat of *Carex*, debris accumulates and builds up the bottom. Davis's researches have shown that this plant is one of the most important in the formation of peat.

In general this association is succeeded by the *Chamaedaphne calyculata* association, altho occasionally the willow thicket may follow.

List of the Species of the Carex filiformis Association:

DOMINANT SPECIES.

Carex filiformis.

SECONDARY SPECIES.

Potentilla palustris. *Glyceria borealis.*

INVADING SPECIES.

Chamaedaphne calyculata. *Salix lucida.*
Salix pedicellaris. *Iris versicolor.*
Spiraea salicifolia.

The Chamaedaphne calyculata Association.

Second in importance only to the *Carex filiformis* as a bog association, is the *Chamaedaphne* association. In this region it is present in several small bogs. The best illustration of it is Silver Lake, a little south of Bryant's hotel, shown in Plate 8. This little lake was, at some early day, a bay of Douglas Lake. Plants of the heath family thuroly dominate the association, but in addition there is a sprinkling of showy secondary species. This association does not extend out into the open water as some of the previous ones have. It is dependent upon the presence of a previous association in which it can obtain a foothold. Usually this is the *Carex filiformis* association, into which the *Chamaedaphne* very readily invades. The floating mat is taken hold of as tho it were normal ground. Occasionally this invasion is so very rapid, especially during the year or two following a burn, that *Chamaedaphne* apparently is pushing its way out into open water. When cases of this nature were more carefully investigated, it was clearly seen that the pure *Carex filiformis* association was narrow and that the *Chamaedaphne* had grown thru it and the projecting ends grew out into the water, but there they could not support an upright growth of stems and leaves.

In general this association is succeeded by an association of shrubs but in this region this is not often the case. Here the succeeding association is usually a bog tree association, such as the *Larix* and *Thuja* associations, as shown in the background of Plate 9. In some of the newly forming bogs, willow thickets, or more often, thickets of *Myrica gale* and *Alnus* follow the *Chamaedaphne*. In cases of severe disturbance of natural conditions, as by fire, the aspen association will follow the *Chamaedaphne*. One case is at hand where a burnt-over area of *Chamaedaphne* came up to a *Calamagrostis* meadow.

List of the Species of the Chamaedaphne Association:

DOMINANT SPECIES.

Chamaedaphne calyculata.
Sphagnum spp.
Kalmia polifolia.
Andromeda glaucophylla.
Vaccinium oxycoccus.

SECONDARY SPECIES.

Menyanthes trifoliata.
Sarracenia purpurea.
Calopogon pulchellus.
Aspidium thelypteris.
Scirpus cyperinus pelius.
Eriophorum virginicum.
Carex pauciflora.
Habenaria blephariglottis.
Epilobium coloratum.
Osmunda regalis.
Osmunda cinnamomea.
Cypripedium acaule.

RELIC SPECIES.

Nymphaea americana (rare).
Smilacina trifolia (in burnt-over places).

INVADING SPECIES.

Picea mariana (seedlings).
Picea mariana f. *brevifolia.*
Larix laricina (some dead trees and a few seedlings).
Thuja occidentalis (seedlings).
Gaylussacia baccata f. glaucocarpa.
Pyrus arbutifolia atropurpurea.
Ilex verticillata.
Quercus rubra (seedling).
Populus tremuloides.
Calamagrostis canadensis.
Vaccinium vacillans.
Nemopanthes mucronata.
Betula alba papyrifera (seedlings).
Populus grandidentata.
Pinus strobus (few seedlings 0.4M).
Vaccinium canadense.

The Calamagrostis canadensis Association.

On a patch of land, near the source of Maple River, burnt over in 1908, meadow grasses have developt and at the present time form a patch of typical meadow, limited in area tho it is. Some dead stems of *Chamaedaphne* and some not entirely burnt tree stumps, however, indicate that the formation of the meadow is very recent. The larger part of the meadow was occupied by a rank growth of *Calamagrostis canadensis* and *Calamagrostis inexpansa*, the former of which was by far the more abundant. Mixt in among the grasses and usually much dwarft on account of the lack of light, were several secondary species, more typical of other associations, together with a few seedling trees. The meadow was in saturated soil, separated from Douglas Lake by a belt of *Typha latifolia*.

List of the Species of the Calamagrostis canadensis Association:

DOMINANT SPECIES.

Calamagrostis canadensis.
Cinna arundinacea.
Calamagrostis inexpansa.

SECONDARY SPECIES.

Eupatorium perfoliatum.
Scutellaria galericulata.
Hypericum virginicum.
Oxypolis rigidior.
Fragaria virginiana.
Campanula aparinoides.
Polygonum amphibium.
Lysimachia terrestris.
Lysimachia thyrsiflora.
Equisetum laevigatum.

RELIC SPECIES.

Sagittaria latifolia.
Typha latifolia.
Iris versicolor.
Dulichium arundinaceum.
Potentilla palustris.
Glyceria borealis.

INVADING SPECIES.

Populus tremuloides.
Populus balsamifera.
Salix discolor.
Fraxinus nigra.

The Iris versicolor Association.

This composit association was often present around the edges of bogs, along the roadsides, along the edges of thickets, and in burnt-over land which had not yet become dominated by either shrubs or trees.

List of the Species of the Iris versicolor Association:

DOMINANT SPECIES.

Iris versicolor.
Aspidium thelypteris.
Eupatorium purpureum.
Lycopus americanus.
Eupatorium perfoliatum.

SECONDARY SPECIES.

Cirsium muticum.
Glyceria borealis.
Eriophorum viridi-carinatum.
Cinna arundinacea.
Hypericum virginicum.
Lysimachia terrestris.
Asclepias incarnata.
Lobelia cardinalis.
Scutellaria galericulata.
Prunella vulgaris.
Rubus triflorus.
Mimulus ringens.
Dulichium arundinaceum.
Polygonum amphibium.
Roripa palustris hispida.
Campanula aparinoides.
Rumex crispus.

RELIC SPECIES.

Typha latifolia.
Potentilla anserina.
Potentilla palustris.

INVADING SPECIES.

Sambucus canadensis.
Cornus stolonifera.
Acer rubrum (seedlings).
Spartina michauxiana.
Salix lucida.
Salix spp.
Thuja occidentalis (seedlings).

The Salix-Cornus Thicket Association.

Along the borders of some of the cedar bogs, but especially along roads thru them, and surmounting the bluff or dune at the limit of ice work around Douglas Lake, occurred this thicket association. The soil in which it grew was wet, altho in certain cases there was a surface layer of nearly dry sand. The association is characterized by the growth of willows, of which *Salix lucida* is the most prominent. This is shown in Plate 7b. In good situations this thicket growth may attain the proportions of a grove of small trees but usually before that time, seedlings of the succeeding association have come in and transformed the area into a bog. In drier situations a stand of red pine may succeed such a thicket.

List of the Species of the Salix-Cornus Thicket Association:

DOMINANT SPECIES.

Salix lucida.
Salix discolor.
Salix rostrata.
Salix glaucophylla.
Salix serissima.
Salix pedicellaris.
Rosa carolina.
Viburnum cassinoides.
Cornus stolonifera.
Spiraea salicifolia.
Sambucus racemosa.
Sambucus canadensis.
Prunus virginiana.
Lonicera dioica.
Viburnum opulus.

SECONDARY SPECIES.

Osmunda regalis.
Onoclea sensibilis.
Glyceria nervata.
Solidago graminifolia.
Ranunculus pennsylvanicus.
Mentha arvensis canadensis.
Aster novae-angliae.
Aster spp.
Solidago canadensis.
Solidago spp.
Carex festucacea.
Rhus toxicodendron.
Polygonum cilinode.
Ribes cynosbati.
Ribes prostratum.
Polygonum aviculare.
Carex retrorsa.
Bromus ciliatus.
Equisetum laevigatum.
Smilacina stellata.
Campanula aparinoides.
Trifolium repens.
Thalictrum dasycarpum.
Potentilla monspeliensis.
Mimulus ringens.
Psedera quinquefolia.
Agropyrum sp.
Muhlenbergia sp.
Clematis virginiana.
Comandra umbellata.
Gnaphalium uliginosum.
Hypericum canadense.

RELIC SPECIES.

Eupatorium perfoliatum.
Eupatorium purpureum.
Asclepias incarnata.
Scutellaria galericulata.
Myrica gale.
Epilobium angustifolium.
Scirpus cyperinus pelius.
Oxypolis rigidior.
Lobelia cardinalis.
Naumbergia thyrsiflora.
Phragmites communis.
Typha latifolia.
Lysimachia terrestris.

INVADING SPECIES.

Populus tremuloides.
Ulmus fulva.
Alnus incana.
Betula alba papyrifera.

The Salix-Cephalanthus Association.

Along parts of the shores of Douglas and Burt Lakes and around some of the bogs in the region was a poor representation of this association which is so abundant along the Illinois River in central Illinois. The association was characterized by dwarf plants of *Salix longifolia* growing in water-soakt ground. This willow commences its develop-

ment in shallow water occupied by the *Scirpus americanus* association either thru the germination of seeds or by the sprouting of twigs carried there by wind or water. In other places, development is initiated in open water by the lodgment of twigs or branches during storms. The willow develops into little bushes, seldom over a foot or two high, whether growing in water, in the sand, or in gravel. The stems are usually more or less uprooted and pusht towards the land—probably the result of ice work during the winter. This association extends landwards only where the sand is low and level so that the water table is virtually at the surface. Secondary species associating with this willow were merely wet sand preferring species, growing there naturally and not such as usually characterize this association. Usually there was a strip of open sand between the upper limits of this association and the fringing dune. Occasionally, on low, wet shores, a succession from this association to a *Salix-Cornus* thicket was indicated.

In the boggy areas of this region, where this association occurred, it occupied the ground just at the water table, altho it may extend down into standing water. It was essentially a thicket of low willows, mostly *Salix longifolia*, with which was associated *Salix pedicellaris* and *Spiraea salicifolia*. Here the association alternates with the *Chamaedaphne* association in position just above the *Carex filiformis* association. Between it and the aspens there was usually a very sharp tension line which in a few cases was occupied by the *Iris* association.

The season of 1911 did not reveal the presence of *Cephalanthus* in the region.

The Myrica gale Association.

This association of low, wet-ground preferring shrubs, characterized by *Myrica gale*, occurs in most of the newly-forming bogs and in places along the shore of Douglas Lake. Accompanied by *Salix candida* or *Salix pedicellaris*, *Myrica gale* is one of the first shrubs to appear in the development of a cedar bog from a beach pool. The association is composed of low bushes but very little if at all higher than the sedges which have preceded it. It usually is followed by a stage of higher bushes, as *Alnus* or *Pirus* and subsequently is replaced by *Thuja*. The stage of higher shrubs is not necessary, however, for in several of the new bogs the seedlings of cedar and spruce are present in the *Myrica* and show all evidences of rapid development.

List of the Species of the Myrica gale Association:

DOMINANT SPECIES.

Myrica gale.
Salix candida.
Salix pedicellaris.

SECONDARY SPECIES.

Solidago graminifolia.
Campanula uliginosa.
Thalictrum dasycarpum.
Carex lenticularis.
Galium boreale.
Polygonum cilinode.
Carex spp.
Hierochloe odorata.
Panicum sp.

RELIC SPECIES.

Potentilla anserina.
Calamagrostis inexpansa.
Lysimachia terrestris.
Cinna arundinacea.
Iris versicolor.
Salix longifolia.

INVADING SPECIES.

Populus tremuloides (seedlings).
Alnus incana.
Rosa carolina.
Salix lucida.
Cornus stolonifera.
Betula alba papyrifera (seedlings).
Thuja occidentalis (seedlings).
Betula lutea (seedlings).
Rosa blanda (near dune bases).
Populus balsamifera.
Fraxinus nigra (seedlings).

The Pyrus-Vaccinium Thicket Association.

Invading either the *Myrica gale* or the *Salix-Cornus* associations, where they occur in bogs or along roadsides, is an association of larger shrubs, characterized by *Alnus incana* and *Pyrus arbutifolia.* The association is not typically developt in this region, but it is well suggested by the occurrence of these typically dominant species. As far as explorations disclosed, there were no species of *Vaccinium* present in this association in the region. Farther south *Vaccinium* is usually abundant. This association gives place to the *Thuja* association which it immediately borders.

List of the Species of the Pyrus-Vaccinium Association:

DOMINANT SPECIES.

Pyrus arbutifolia.
Alnus incana.
Pyrus arbutifolia atropurpurea.

SECONDARY SPECIES.

Onoclea sensibilis.
Salix lucida.
Psedera quinquefolia.
Cornus circinata.

RELIC SPECIES.

Lobelia cardinalis.
Carex spp.
Mentha arvensis canadensis.
Iris versicolor.
Eupatorium purpureum.
Eupatorium perfoliatum.
Aspidium thelypteris.
Lycopus americanus.
Aquilegia canadensis.
Decodon verticillatus.

INVADING SPECIES.

Fraxinus nigra (seedlings).
Acer rubrum (seedlings).
Thuja occidentalis (seedlings).
Ulmus americana (seedlings).

The Elymus Dune Association.

In many places along the shores of the lakes the limit of ice work is indicated by what appear to be a fringing dunes. It is, however, only

in exceptional cases that they were formed as normal dunes, namely, by the collecting of sand around a nucleus. They were usually the result of a heaping up of the sand by the pushing of the ice of the lake. Generally the aspen association takes possession of these ridges. A somewhat different composition of species, however, always obtained. *Populus tremuloides* is accompanied by less xerophytic trees such as red maple, white birch, white cedar, *Populus balsamifera*, red oak and Norway and white pines. Associated with the trees there may be shrubby plants as poison ivy, rose (*Rosa blanda*), bearberry, blueberries (*Vaccinium pennsylvanicum* and *V. canadense*), red-osier dogwood, willows, together with herbaceous plants as wild rye, *Spartina michauxiana*, *Aster laevis*, etc.

Other stations on the fringing dune were occupied almost exclusively by a stand of willows, three to five or six feet high, with a few of the normal secondary species of that association.

In stations along South Fishtail bay and in a few stations along the southwestern shore of Douglas Lake, this ridge appeared more like a real dune. It was covered by a dense growth of *Elymus canadensis* in which might be mixt *Spartina michauxiana* and less frequently a few secondary species as *Apocynum cannabinum*, bearberry and blueberry (*Vaccinium pennsylvanicum*). Such a dune is shown in Plate 9.

There were no plant associations leading up to this dune association. It is an example of poineer occupation of a newly formed physiographic habitat. The presence of bearberry indicates that normal succession tends towards the development of a heath but the heath is so feebly represented in this region that before such a stage can obtain existence, other associations replace it. Of these the willow (*Salix-Cornus* Association), and the aspens are most frequent. In other places pines and even hardwoods may succeed the *Elymus* association. In cases where the ice merely pushes up over the shore into the surrounding vegetation, in the absence of any dune-like formation, *Elymus* was not found. The upland association ended abruptly at the limit of ice work.

The Heath Association.

A few patches of bearberry, *Arctostaphylos uva-ursi*, growing under the pines that fringe South Fishtail bay is all that remains to indicate the former presence of the heath association in this region. These plants seen to be persisting, but rarely show any evidence of spreading out into genetically lower associations. With the bearberry was associated the blueberry (*Vaccinium pennsylvanicum*).

The Pinus banksiana Association.

This association of conifers, which develops on the poorest land adaptable for tree growth, was not formerly present in the region, altho scattering trees of *Pinus banksiana* occurred here and there. With the extreme and thuro burning that has occurred on the land formerly occupied by *Pinus strobus* the soil has been very much depleted. In the area between Douglas Lake and Pellston, aspens have followed lumbering and thuro burning, but the aspens have made but little headway. Seedlings of *Pinus banksiana* are coming in here and there among the aspens.

Whether they are sufficiently numerous and whether the soil is too poor to allow the replacement of the stand of white pine are things which the future must disclose. These seedlings are all that there is to suggest the presence of this association.

The Pinus strobus Association.

In former days this association covered the greater part of the region, but at the present time there is not a typical station in this area. It is represented only by seedlings, young trees and a few seeding trees. scattered among other associations, particularly the aspens. Accordingly from present-day evidence there is but little to say about this association. The pines occupied sandy, well-drained land which contained some humus. The pineland was virtually self-perpetuating. Between it and the cedar bogs the tension line was sharp and succession was virtually nil and remained so except when the water table was decidedly changed. At that time succession might commence but probably did not proceed far, as the high and low water cycles came oftener than the lives of the trees. With the increase of food material in the soil, hardwoods appeared and were very gradually tending to displace the pines.

Then the lumberman came. The pines were all removed and the ground burnt, accidentally or otherwise. Following this devastation the fire associations made their appearance and just now the pine is beginning to come back. It occupies the position of invader in the aspens. *Pinus resinosa* is well represented by numberless seedlings and several young trees, some of which have already begun to seed. *Pinus strobus* is not well represented and there are scarcely a dozen trees of *Pinus banksiana.* Pine seedlings develop readily in the light shade of the aspens and in due course of time supplant them altogether. See Plate 10.

The pine association of the near future will occupy a greater area in this region than the one that was cut, because virtually all of the typical aspen association goes to pine land and in addition the hardwood land which was thuroly burnt goes thru aspen to pine. If the country were allowed to remain undisturbed and no fires occurred, it is obvious that in the course of time, hardwood would supplant the pine which is developing now, but as conditions now stand, the pines are gaining, rather than losing out to the hardwoods. In the hardwood areas that now occur, there are frequently large pine trees which serve as relics of their former dominance and show what the trend of succession has been in the past. As no seedling pines occur in the average hardwood, it is evident that hardwoods can replace pine and perpetuate themselves against the pines, provided the soil is sufficiently rich.

Where the present stands of pine are densest the ground flora frequently contains the following species: *Myrica asplenifolia*, mullein, horse-weed, *Panicum depauperatum*, bracken fern, *Agrostis alba*, goldenrods and asters, altho this assemblage does not present the typical structure of an association.

The Larix laricina Association.

This association, the first of the bog tree associations in the genetic arrangement, occurred over a long stretch of country northwest from

Ingleside. It occupied the boggy lowland soils, which are water-soakt or nearly so all of the time.

The association consists of the dominant species, *Larix laricina* and *Acer rubrum*, with very few secondary species, nearly all of which are relics of the preceding herbaceous and shrubby growth. At the present time there are no typical examples of this association in this general area, altho it is well represented farther south in Michigan. A distant view of the boggy land northwest of Ingleside would lead one to the impression that it was an extensively and typically developt *Larix* association. Closer investigation does not bare out the impression. Only the tallest trees are tamarack. They are being killed off by the larvae of the sawfly. In between them are countless trees of spruce (*Picea mariana*) and cedar (*Thuja occidentalis*), many of which lack but ten to fifteen feet of topping the tamarack. Tamarack seedlings are rather scarce, while spruce and cedar seedlings are very abundant.

The tamarack is normally the first tree to appear in the *Chamaedaphne* bog. This fact is very apparent in bogs thruout Michigan and the author has observed it many times in southern Michigan. Silver Lake in this region is the only good example of this in the vicinity. A severe fire was followed by an extensiv development of *Chamaedaphne* into which tamarack is commencing to invade, followed shortly by spruce, *Picea mariana*, often appearing as the xerophytic modification to which the name *Picea brevifolia* was given by Peck. The development of this arboreal association cuts off the light from the ground and consequently nearly eliminates the ground vegetation. The development of tamaracks paves the way for genetically higher trees, the next to appear usually being the black spruce (*Picea mariana*). In this area, at virtually the same time, the white cedar (*Thuja occidentalis*) also appears. These two species grow together, seemingly without competition for a number of years and they finally succeed in dominating the ground when they reach a height nearly that of the tamaracks. See Plate 10b. The tamaracks, however, readily remain as relics. From data kindly supplied from the personal observations of Mr. C. E. Spicer in the vicinity of Crystal Lake, Benzie County, Michigan, about 100 miles south of this area, this cycle may represent as short a time as 35 years.

Burning of ground occupied by this association results in the rather rapid succession thru the fireweed and *Chamaedaphne* associations to *Larix*. When cedar bogs are severely burnt a tamarack stage next precedes the invasion of cedar. Unless the burn is severe there is no *Larix* stage unless some other factor, as proximity of seeding trees, should enter strongly into the case.

Tamarack easily persists as a relic in the cedar bog and will continue to do so as long as openings occur where tamarack seedlings have a chance to develop. Tamarack seedlings grow faster than spruce and cedar seedlings for a number of years. The fact that spruce and cedar seedlings can develop in the shade of the tamarack, while the tamarack seedling virtually requires the maximum of light—sunlight—precludes the development of tamarack except in openings. Such openings will have to occur time and time again or else the dying of the old trees might leave no seedlings to reproduce it.

List of the Species of the Larix laricina Association.

DOMINANT SPECIES.

Larix laricina.
Sphagnum spp.
Acer rubrum.
Fraxinus nigra.

SECONDARY SPECIES.

Cornus canadensis.
Fragaria virginiana.
Rubus triflorus.
Aralia nudicaulis.
Aster junceus.
Eupatorium purpureum.
Cypripedium hirsutum.
Ribes cynosbati.
Lonicera canadensis.
Coptis trifolia.
Galium triflorum.
Pyrola asarifolia.
Pyrola secunda.
Habenaria flava.
Geum macrophyllum.
Potentilla canadensis.
Cornus circinata.
Solidago uliginosa.
Mitella nuda.

RELIC SPECIES.

Pinus resinosa (a few dead, standing trees).
Populus tremuloides.
Salix pedicellaris.
Cornus stolonifera.
Chamaedaphne calyculata.
Salix rostrata.
Betula alba papyrifera.
Quercus rubra (very few).
Ledum groenlandicum.
Rosa carolina.

INVADING SPECIES.

Thuja occidentalis.
Picea mariana.
Fagus grandifolia.
Abies balsamea.
Betula lutea.
Acer spicatum.

The Thuja occidentalis Association.

Nearly all of the boggy parts of this region are covered with this association of conifers. The land they occupy is low, water-soakt or very nearly so—which prevents the development of genetically higher associations—and cold. A general view of Reese's bog located at the north end of Burt Lake is shown in Plate 11.

The association is composed of trees of which the following—order of abundance as named—compose virtually all of the growth: white cedar (*Thuja occidentalis*), balsam (*Abies balsamea*), black spruce (*Picea mariana*) and red maple (*Acer rubrum*). Other trees as white pine (*Pinus strobus*), black ash (*Fraxinus nigra*), and white spruce (*Picea canadensis*) also occur here and there. These trees form a dense, often nearly impenetrable jungle, illustrated in Plates 12 and 13a. The ground cover is formed by needles, leaves, decaying logs and other debris in which a few characteristic plants that prefer cold situations are to be found. A few of the more typical species are *Moneses uniflora*, *Cornus canadensis*, *Pyrola secunda*, *P. asarifolia*, *Clintonia borealis*, *Ledum groenlandicum*, *Trientalis americana*, *Chiogenes hispidula* (shown

in Plate 14.), *Mitella nuda*, *Coptis trifolia*, *Mitchella repens*, *Viola blanda*, and *Phegopteris dryopteris*. Others which are not so typical occur in openings where sufficient light is admitted to the ground: *Rubus triflorus*, *Linnaea borealis americana*, *Aralia nudicaulis* and *Cypripedium hirsutum*.

In normal genetic succession this association follows the *Larix* association quite closely. It may however, follow *Chamaedaphne* without an intervening *Larix* stage as is the case in the bog southeast of south Fishtail Bay. It is the climatic association for the boggy ground and as long as the ground remains in this condition no other association can replace it. It is separated from the aspen or the hardwood associations, when in juxtaposition with them, by clear-cut tension lines, in the making of which the water-table height seems to be the most potent single factor, as obvious variations of that factor at times in the near past have found their expression in inroads of one association into the other and their persistence there as relics. From the *Picea-Abies* association there is no such well-markt tension line, but as there is only a single example of the *Picea-Abies* association it is difficult to give adequate separation from the data at hand. One obvious difference, however, is that the *Picea-Abies* has developt in land which is drained by the little streams which run thru it fairly rapidly, while the cedar bog land is drained very slowly if at all except by seepage. In this region the *Picea-Abies* is the logical association to succeed the cedar bog but headway in that direction is virtually nil.

Incursions of fire and lumbering are rather readily replaced by cedar bog species without intervening stages. In case of severe burns, however, there is a fireweed stage and not infrequently a tamarack stage, both of which are past thru rather rapidly and the cedar again becomes dominant. Only rarely is there more than an indication of an aspen stage, for in wet ground the aspens cannot do so well as the bog trees and the aspens that may have started soon succumb to the cedar, which very easily invades such areas.

List of the Species of the Thuja occidentalis Association:

DOMINANT SPECIES.

Thuja occidentalis.
Picea mariana.
Larix laricina.
Abies balsamea.
Acer rubrum.
Fraxinus nigra.
(*Pinus strobus.*)
(*Picea canadensis.*)

SECONDARY SPECIES.

Clintonia borealis.
Ledum groenlandicum.
Taxus canadensis.
Chiogenes hispidula.
Streptopus amplexifolius.
Moneses uniflora.
Acer spicatum.
Pyrola secunda.
Pyrola asarifolia.
Mitella nuda.
Coptis trifolia.
Smilacina trifolia.
Trientalis americana.
Drosera rotundifolia.
Prunella vulgaris.
Viola reniformis.
Phegopteris dryopteris.
Asplenium filix-foemina.

Maianthemum canadense.
Rubus triflorus.
Cornus canadensis.
Linnaea borealis americana.
Aralia nudicaulis.
Mitchella repens.
Equisetum litorale.
Lonicera canadensis.
Cypripedium hirsutum.
Cypripedium pubescens.
Cypripedium parviflorum.
Gaultheria procumbens.
Fragaria virginiana.
Carex intumescens.
Carex retrorsa.
Carex aurea.
Carex leptalea.
Carex crinita var?
Carex crinita.
Carex hystericina.
Carex sp? (122).
Carex rostrata.
Botrychium virginianum.
Sanicula gregaria.
Geum triflorum.
Ranunculus recurvatus.
Ranunculus hispidus.
Lilium canadense x superbum.
Lilium philadelphicum andinum.
Aspidium thelypteris.
Aspidium noveboracensis.
Pyrola asarifolia incarnata.
Aquilegia canadensis.
Caltha palustris.
Mimulus glabratus jamesii.
Marchantia polymorpha.
Ribes cynosbati.
Acer pennsylvanicum.
Aster macrophyllus.
Habenaria hyperborea.
Habenaria obtusata.
Habenaria psycodes.
Cladonia spp.
Trillium grandiflorum.
Ribes triste albinervium.
Ribes hudsonianum.
Medeola virginiana.
Veronica anagallis-aquatica.
Galium triflorum.
Lonicera glaucescens.
Onoclea sensibilis.
Diervilla lonicera.
Polytrichum sp.
Solidago uliginosa.
Eupatorium purpureum.
Lycopodium clavatum.
Anemone canadense.
Actaea rubra.
Epigaea repens.
Glyceria nervata.
Marrubrium vulgare.
Arisaema triphyllum.

Secondary species occurring along the roads, introduced in this habitat:

Pteris aquilina.
Juncus bufonius.
Trifolium repens.
Anaphalis margaritacea.
Danthonia spicata.
Agrimonia gryposepala.
Achillea millefolium.
Cerasteum vulgatum.
Carex bebbii.
Aralia racemosa (1 plant).
Silene noctiflora.
Erigeron pulchellus.

RELIC SPECIES.

Larix laricina (old trees).
Acer rubrum (old trees).
Sphagnum (very abundant).
Alnus incana.
Salix lucida.
Salix rostrata.
Salix discolor.
Salix cordata.
Carex crinita.
Juncus effusus.
Chamaedaphne calyculata.
Betula alba papyrifera.
Populus tremuloides.
Prunus pennsylvanica.
Ilex verticillata.
Pyrus melanocarpa.
Myrica gale.
Rhamnus alnifolia.
Vaccinium oxycoccus.
Eriophorum viridi-carinatum.

INVADING SPECIES.

Tsuga canadensis.
Pinus strobus.
Tilia americana (very few but one tree large).
Betula alba papyrifera.
Picea canadensis.
Betula lutea (young and old trees).
Pyrus americana.
Populus tremuloides.

The Picea-Abies Association.

This more northern association may have been better represented in the region at an earlier date, but at the present time it is suggested by the extensive development of white spruce (with some black spruce) and balsam near the upper end of the gorge which opens into Burt Lake. The ground is kept water-soakt by the cold springs at the head of the gorge but differs from the typical bog situation in being fairly rapidly drained.

As mentioned above, the extensive development of spruce and balsam characterize the association. Mixt in somewhat with them but particularly above their upper margins on the sides of the gorge are a number of large red and white pines. On raised portions between the springs and between the streams that flow from some of the different springs, there are some large-sized trees of *Betula lenta*, *Betula lutea*, *Tilia americana*, *Acer saccharum*, and seedlings of these same trees, but particularly *Acer saccharum* together with seedlings of *Fraxinus nigra* and *Fagus grandifolia*. Towards Burt Lake the association grades off into the typical cedar bog. Thruout the association, but best developt near its margin with the cedar bog, is the mountain maple (*Acer spicatum*). There is virtually no ground vegetation in the denser parts of this association.

From the character of the seedlings and young trees that are present the higher parts of this association are tending towards a hardwood forest while the lower parts will remain a mixtur of this association and the cedar bog.

Lumbering and light burning in this association lead to the instigation of the fireweed association followed almost immediately or at least within a year by the bramble association which in due course of time is replaced either by hardwood in the drier, better drained situations or by *Picea-Abies* in the lower, wetter situations. No severe burns were found in this immediate area but it can probably be safely presumed that in the advent of a severe burn the drier, better drained parts would go to aspen and then to pine, while the lower, wetter parts would become dominated by cedar bog species, possibly with, and probably without a tamarack stage.

List of the Species of the Picea-Abies Association.

DOMINANT SPECIES.

Picea canadensis.
Abies balsamea.
Betula lutea.

SECONDARY SPECIES.

*Pyrus americana.**	*Carex hystericina.*
*Taxus canadensis.**	*Clintonia borealis.*
*Acer spicatum**	*Amelanchier canadensis.*
*Cornus canadensis.**	*Circaea alpina.*
*Maianthemum canadense.**	*Galium triflorum.*
Rubus triflorus.	*Arisaema triphyllum.*
Impatiens biflora.	*Geum triflorum.*
Aspidium spinulosum.	*Trillium grandiflorum.*
Mitella nuda.	*Pteris aquilina* (not much).
Caltha palustris.	*Epigaea repens.*
Larix laricina (seedlings).	*Trientalis americana.*
Viola blanda.	*Smilacina racemosa.*
Mitchella repens.	*Aralia nudicaulis.*
Chimaphila umbellata.	*Phegopteris dryopteris.*
Osmunda cinnamomea.	*Habenaria orbiculata.*

The secondary species markt with an asterisk are the most abundant.

RELIC SPECIES.

Thuja occidentalis.	*Pinus resinosa.*
Pinus strobus.	*Carex crinita.*
Typha latifolia.	

INVADING SPECIES.

Tsuga canadensis.	*Acer saccharum.*
Tilia americana.	*Fraxinus nigra.*
Acer saccharum.	*Fagus grandifolia.*
Betula lenta.	*Pinus strobus.*
Betula lutea.	(Represented by some large trees but mainly by seedlings.)
Quercus rubra. (Represented by a few large-sized trees).	*Aralia racemosa.*

The Oak (Quercus) Association.

The red oak (*Quercus rubra*) is here nearly at its northern limit of distribution and scattered trees and a number of seedlings are all there is to indicate an oak association such as is abundant farther south of this area. The oaks develop in the aspens and appear to represent a stage which may be interposed between aspens and pine. The oaks, however, are not a necessary step before pine. An occasional large tree of *Quercus rubra* in the hardwoods may indicate that the hardwoods can succeed oaks in this region, but on account of their isolation and size it seems more likely that these trees started with the seedling hardwoods and kept pace with them. This does not predicate that an association has been succeeded.

The Beech-Maple (Fagus-Acer) Association.

This association of forest trees is still fairly well represented in different parts of this region, but usually only in those parts which have been least accessible to lumbermen. It is scarcely to be doubted that they will all be cut within the next few years. The hardwood forests occur on the best lands of the region, occupying the land immediately north of Douglas Lake, a stretch of upland south of the west end of Douglas Lake shown in Plate 15, and extending along Burt Lake, shown in Plate 13b. There are other small areas scattered here and there, which are more or less typical of this association but usually fire and lumbermen have wrought havoc with them. Between Douglas Lake and Lake Huron there were large tracts of hardwoods, which within the past two decades have been cut and the land used for agricultural purposes. Hardwood land in this country is a paying proposition for agricultural use. This is not usually the case with pine land. Oats and potatoes are successfully grown for the market together with a certain amount of truck for home consumption.

The hardwood forests occur on the better classes of land. It may vary from sand to clay but there is always at least a fair admixtur of humus which is continually bilt up by each year's leaf-fall. The slope of the land varies considerably but it is usually rolling and well drained.

Several trees enter into the composition of the beech-maple forest association and there is considerable variation in composition in different stations yet the structur and type of vegetation is quite uniform thruout. Where the trees are best develop t and the association is most typical or rather least disturbed by the inroads of man it is composed of about 48% of *Fagus grandifolia*, 35% of *Acer saccharum*, 15% of *Tsuga canadensis* and the remaining 2% scattered among *Abies balsamea, Fraxinus americana, Betula lutea, Tilia americana, Populus balsamifera* and *Pinus strobus*. The trees are usually large and very tall with but very few branches, as shown in plate 15. The ground vegetation in such places is virtually nil. In openings, however, seedlings of the dominant trees and many secondary species are present, sometimes in abundance as shown in plate 16a. As a general rule when this association occupies the sandy upland soils the proportion of maple is much greater than that of beech, while the reverse of this is true of the more clayey, wetter, lower land soils. Exceptions occur in which even in the moister soils the proportion of maples is greater. The woods toward the northwest of Burt Lake are a very good example of the case in hand. Seeding trees of the dominant species are present in the region in abundance and seedlings are usually very abundant in the open places in these woods and in addition spred out into the aspens for considerable distances. This association is not so subject to fire, because the hardwood does not catch fire so easily nor does it burn so readily. In case of a fire, unless it is too severe, the trees can reproduce by growth from the stumps.

Secondary species of the dense growth of this association are rather few and far between and consist mainly of the seedlings of the dominant trees, particularly the maple and beech, together with *Aralia nudicaulis, Maianthemum canadense, Clintonia borealis, Trientalis americana, Streptopus longipes*, and *Polygonatum commutatum*, shown in Plate

17. Towards the margins and along the roads they become more numerous and varied and the small tree, *Acer pennsylvanicum*, often assumes considerable importance. In openings, however, whether brot about naturally by the fall of a large tree or otherwise by fire, clearing, etc., so that light is admitted to the ground, a very varied growth follows which may often be rather rich in number of species. This is more likely to be the case on the clayey rather than on the sandy soils, such as one finds northwest of Burt Lake. A number of plants are found in such localities, which, tho typical of hardwood areas farther south even on poorer ground, are not usually found in the hardwood on the sandy ground which it usually occupies in this region. A number of such species are *Filix bulbifera*, *Allium tricoccum*, *Hystrix patula*, *Actaea alba*, *Adiantum pedatum*, *Arisaema triphyllum*, *Caulophyllum thalictroides*, *Circaea intermedia Uvularia grandiflora*, *Osmunda claytoniana* and *Viola scabriuscula*.

Ages ago this association came into possession of the ground which it occupies at the present time. Now it is supreme and self perpetuating in the land it occupies and holds its own, year after year, even in spite of some slashing, unless severe fire runs thru its territory and burns the humus out of the ground. This causes a recommencement of the series of successions. This may or again it may not lead back to the beech-maple. This association, which is climatically dominant over the north central states which includes Wisconsin, Mich., Ill., Indiana and Ohio, is dominant in this region only when the soil is favorable. All the evidence which is at hand shows that the boundaries of the hardwood areas are gradually being drawn in rather than expanding in extent. It is true, however, that man and especially the coming of fire have been very instrumental in bringing this about. The seedling hardwoods do very well in hardwood soil when they have sufficient light. In the vicinity of hardwood areas there are great numbers of seeds scattered in the aspens which are growing on pine land. Many of these germinate especially during wet springs, but very few live out the summer. Those that do and continue to eke out an existence are dwarft and stunted and it is quite obvious that they are with difficulty holding their own. As this is otherwise in the case of the aspens and the pine seedlings in them, it is obvious that there is no succession going on at the present time from the conifer type to the hardwood type. This region is part of the tension zone between the conifer province and the deciduous forest province, and, in view of the fact that invading associations of the same type of vegetations must be able to displace those already occupying the ground, it is easily seen that the association holding the ground can withstand the inroads of the invading association except under the best conditions for those associations. Accordingly the pine—represented by aspens at the present time—will occupy all of the land from which the hardwood is excluded because of the fact that the margin of suitability of the soil is not sufficiently high. That before the advent of lumbering the genetic conditions were such as one would expect to find in this part of Michigan,* namely that the hardwoods were gradually displacing the pines, is evidenced in the region north of North Fishtail Bay. Altho this station is characteristically hardwood there

*Whitford, H. N. The Genetic Development of the Forest in Northern Michigan. Bot. Gaz. 31: 289-325. May 1901.

has been a rather high representation of *Pinus strobus* and *P. resinosa*. The depletion of the soil by fire has been the greatest single factor in overturning the normal genetic trend.

When hardwood land is severely burnt over, the humus is burnt out of the soil and the succession that is instigated goes thru the fireweed associations to aspens or occasionally thru *Pinus banksiana* to *Pinus strobus*. If the burn is not so severe, fireweeds appear to be almost immediately succeeded by birch with some aspen, which in turn is quite likely to be followed by hardwood, altho this is not always the case. In case the burn is light, hardwood succeeds hardwood, altho there may be a number of fireweeds and seedling birches present for a time.

Altho hardwood species—represented by both seedlings and older trees—are not infrequently present in the *Picea-Abies* and the *Thuja* bogs, as they occur in this region, there is no evidence to show that any definit succession is taking place. On the other hand the greater part of the evidence goes to show that no succession is taking place. It is presumed that in the case of a general change in water table level succession might take place because the tension line between hardwood and *Thuja* is very sharp and agrees almost perfectly with a definit hight around each bog where these associations occur in juxtaposition.

List of the Species of the Beech-Maple Association:

A. Trees.

DOMINANT SPECIES.

Fagus grandifolia m and s.[1]
Acer saccharum m and s.
Tsuga canadensis m and s.
Betula lutea m and s.
Tilia americana m and s (few old trees).

SECONDARY SPECIES.

Abies balsamea m and s.
Betula lenta m and s.
Fraxinus americana m and s.
Populus balsamifera (near edge) m.
Ulmus americana (few) m and s.
Prunus serotina (few).

RELIC SPECIES.

Quercus rubra (old trees).
Pinus strobus (old trees).
Acer rubrum (few).
Thuja occidentalis.
Picea canadensis.
Betula alba papyrifera (old trees).
Fraxinus nigra (few young).
Prunus pennsylvanica (few).

INVADING SPECIES.

(In clearings or openings only.)

Pinus strobus (seedlings).
Quercus rubra (seedlings).
Betula alba papyrifera (seedlings and young trees).
Populus tremuloides (seedlings).
Populus grandidentata.
Prunus pennsylvanica.
Acer saccharum.
Fagus grandifolia.
(Seedlings and young trees.)

[1] "m"=matur trees, "s"=seedlings.

B. Shrubs.

SECONDARY SPECIES.

Acer pennsylvanicum.
Viburnum cassinoides.
Cornus circinata.
Lonicera glaucescens.
Vaccinium canadense.

RELIC SPECIES.

Rhus toxicodendron.
Amelanchier canadensis.
Viburnum sp.
Sambucus racemosus.
Acer spicatum.
Salix rostrata.
Alnus incana.
Cornus stolonifera.
Nemopanthes mucronata.
Salix discolor xrostrata.
Salix lucida.
Ostrya virginiana.
Taxus canadensis.
Celastrus scandens (Liana.)

C. Herbs.

SECONDARY SPECIES.

(Growing on sandy loamy soil.)

Aralia nudicaulis.
Maianthemum canadense.
Polygonatum commutatum.
Trillium grandiflorum.
Trientalis americana.
Aster macrophyllus.
Corallorrhiza maculata..
Galium triflorum.
Botrychium virginianum.
Botrychium ternatum intermedium.
Botrychium ramosum.
Aspidium spinulosum.
Streptopus longipes.
Streptopus roseus.
Mitchella repens.
Pyrola secunda.
Carex lupulina.
Carex intumescens.
Poa nemoralis (?)
Osmunda cinnamomea.
Geranium robertianum.
Stellaria media.
Carex laxiflora.
Fragaria virginiana.
Smilacina racemosa.
Medeola virginiana.
Chimaphila umbellata.
Blephilia hirsuta.
Hepatica triloba.
Clintonia borealis.
Lycopodium annotinum.
Epipactis decipiens.
Cornus canadensis.
Viola blanda.
Osmunda claytoniana.
Aralia racemosa.
Juncus tenuis.
Onoclea sensibilis.
Hieracium pratense (Loew).
Arctium minus (in a road).
Nepeta cataria (in a road).
Cynoglossum officinale (in a road).
Onoclea struthiopteris.

Secondary species growing only in Clayey Soil.

Cystopteris fragilis.
Cystopteris bulbifera.
Allium tricoccum.
Hystrix patula.
Adiantum pedatum.
Circaea lutetiana.
Circaea intermedia.
Arisaema triphyllum.
Pyrola elliptica.
Carex spp.
Pilea pumila.
Plantago major.
Polygonum acre.
Apocynum androsaemifolium.
Prunella vulgaris.
Aquilegia canadensis.

Uvularia grandiflora.
Osmunda claytoniana.
Polygonatum biflorum.
Caulophyllum thalictroides.
Actaea alba.
Lactuca spicata.
Viola scabriuscula.
Viola papilionacea.
Mitella nuda.
Asplenium filix-foemina.
Solanum nigrum.
Lactuca spicata integrifolia.
Geum sp.
Aspidium noveboracense.
Impatiens pallida.
Erechtites hieracifolia (few).
Epilobium angustifolium (few).
Aspidium goldianum.

RELIC SPECIES.

Dierrilla lonicera.
Rubus idaeus aculeatissimus.
Epilobium angustifolium.
Erigeron canadensis.
Aralia hispida.
Streptopus amplexicaulis.
Pteris aquilina.
Gaultheria procumbens.
Poa pratensis.
Lycopus americanus.
Rubus triflorus.

THE ASSOCIATIONS OF BURNT LAND.

The Fireweed Association.

This association of rapidly growing and maturing annuals is usually very quick in making its appearance after nearly any burn. During 1911, after a severe burn in the cedar bog southeast of Douglas Lake, matur fireweeds were found in the burnt area three weeks after the fire. The fireweeds prefer a mineral soil, especially the one left after a fire, whence their name. In the region the species of plants which entered most largely into its composition were *Epilobium angustifolium*, *Erechtites hieracifolia* and *Erigeron canadensis.*. The *Epilobium* was by far the most abundant. As an association it is short-lived, often existing for not more than a year, altho individual plants may occur as scattered or isolated relics for a number of years. The succeeding association depends largely upon the severity of the burn and the surrounding associations. In general over the greater part of the area aspens appear and rapidly change the type of vegetation. This is nearly always true on pine land. On hardwood land this is also true in case of severe burns which have burnt the humus out of the ground. In moderate burns there is sometimes a short fireweed stage followed by hardwood directly but more often brambles—especially *Rubus idaeus aculeatissimus*—appear with the fireweeds and with them persist for a number of years befor giving place to hardwood. On bog land fireweeds are rarely followed by aspens but usually seedlings of the bog trees appear within a year or two and the bog gradually becomes reestablisht.

List of the Species of the Fireweed Association:

DOMINANT SPECIES.

Epilobium angustifolium.
Erechtites hieracifolia.
Rumex acetosella.
Erigeron canadensis.

SECONDARY SPECIES.

Chenopodium capitatum.
Chenopodium album.
Chenopodium hybridum.
Amaranthus retroflexus.
Setaria viridis.
Solidago canadensis.
Aster novae-angliae.
Aster spp.
Scirpus cyperinus pelius.
Bidens vulgata.
Polygonum amphibium.

INVADING SPECIES.

Populus grandidentata.
Populus tremuloides.
Pteris aquilina.
Prunus serotina.
Betula alba papyrifera.
Larix laricina.
Thuja occidentalis.
Prunus pennsylvanica.
Acer saccharum.
Aralia hispida.
Rubus idaeus aculeatissimus.
Rubus allegheniensis.

The Bramble Association.

This association of plants growing on burnt and on cleard land has become more extensive since the inroads of man. It consists of a dense growth of red raspberry (*Rubus idaeus aculeatissimus*) and blackberry (*Rubus allegheniensis*) in which a considerable amount of fireweed may often be present. In general this association does not occur on pine land or on other land that has been severely burnt out. It is best developt on cleared hardwood land or after the slashing of *Picea-Abies* territory. It is not usually so well developt on these soil types when the former vegetation was burnt off. It also occurs to a limited extent on cleard or burnt bog land. The secondary species that accompany it are for the most part relics, persisting from the previous association and invaders of the tree types that are to follow.

List of the Species of the Bramble Association:

DOMINANT SPECIES.

Rubus idaeus aculeatissimus.
Prunus pennsylvanica.
Rubus allegheniensis.
Prunus virginiana.
Ribes cynosbati.

SECONDARY SPECIES.

Sambucus racemosa.
Cirsium muticum.
Eupatorium perfoliatum.
Anaphalis margaritacea.
Mentha arvensis canadensis.
Geum triflorum.
Juncus tenuis.
Ranunculus hispidus.
Ranunculus septentrionalis.
Polygonum cilinode.
Solidago canadensis.
Verbascum thapsus.
Epilobium coloratum.

INVADING SPECIES.

Abies balsamea (seedlings).
Acer rubrum (seedlings).
Acer saccharum (seedlings).
Tilia americana (seedlings).
Fagus grandifolia (seedlings).
Picea canadensis (seedlings).
Thuja occidentalis (seedlings).
Sambucus canadensis.
Diervilla lonicera.
Cornus circinata.

RELIC SPECIES.

Erechtites hieracifolia.
Epilobium angustifolium.

The Aspen (Populus) Association.

In addition to the fireweeds, as the herbaceous type of vegetation developing after a fire, and the brambles, as a thicket type, there remains an arboreal post-igneous type of vegetation, the aspens. The aspen association usually secures greater prominence because it is composed of trees which impress the eye to a greater degree and because it is so much longer lived than the other fire associations. At the present day in this region there is no other association so wide-spred in extent nor occupying so many different edaphic conditions as the aspen association. Following the numerous smaller and larger fires of the past ten and more years there are wide variations in the stations in this association depending upon its age. In the younger stages the general character is that of a dense shrubby growth composed of small trees of the dominant species as shown in Plate 16b. Later as these trees grow higher the association assumes the tree type which gives it a different appearance to an observer near at hand. For tree associations this association is relatively short-lived, under ordinary conditions less than 35 years. Frequent fires, however, continue aspen possession for a much longer time.

The association is composed of a large representation of individuals of *Populus tremuloides*, *Populus grandidentata*, *Betula alba papyrifera* and *Prunus pennsylvanica*, with a scattering and usually meager representation of several other tree species, a very few of which are relics which escapt the fire and most of which are invading species of the succeding associations. Among the dominant trees of this association there are certain tendencies of distribution which were constantly noticed, altho no hard and fast lines could be drawn. Of the two species of aspens, which comprize about 80% of the average arboreal growth, *Populus tremuloides* prefers the moister sandy soils while *Populus grandidentata* is much more likely to be found on the drier or more xerophytic situations. Birch, *Betula alba papyrifera*, a very common dominant species, not only prefers the moister situations but almost demands better soil. Consequently it usually found in depressions or hollows and along the edges of the lakes. On original hardwood land the percentage of birch to aspen is much larger than on pine land, very likely on account of the better soil. *Prunus pennsylvanica* is not so abundant in this region and here is a small tree, developing better on hardwood land than on pine land.

The undergrowth of the aspen association is very characteristic. Usually from 85 to 95% of the ground is occupied by *Pteris aquilina* and *Dier-*

villa lonicera as shown in Plate 18. These two species are the most abundantly represented in the different stations of this region but other species may assume greater importance in some of the stations, e. g., *Rhus glabra*, *Gaylussacia baccata*, *Vaccinium pennsylvanicum*, *Vaccinium canadense*, *Gaultheria procumbens*, *Anaphalis margaritacea*, *Gnaphalium decurrens*, *Hieracium venosum*, *Panicum xanthophysum*, etc. A number of other species may also be present which add to the list without greatly affecting the general appearance.

As mentioned above this association is usually immediately preceded by the fireweed association. In general it does not follow the bramble association unless that is very open because aspen seedlings require a maximum of light which is not obtained when the brambles are at all dense. As the aspens are very intolerant of shade* unless they obtain their start first they will be killed out. As the aspens seed early in the spring and grow very rapidly for the first few years they obtain a maximum of light for years. This same intolerance of shade, however, shortens the life of the association, for the aspen seedlings, tho produced in large numbers can not develop without virtually the maximum of light and consequently must wait for openings in the aspens befor this can be obtained. Meanwhile other tree seedlings that are more tolerant are developing in the spaces between the aspens. This makes reproduction more difficult for aspen seedlings. As these other trees grow higher and higher they come to overtop the aspens and shut out light. The aspens, which are not normally long-lived trees even under the best of conditions, cannot withstand this and with their death the station is left in possession of the succeding association. Should another fire come befor this succession has completely taken place, the aspen association is rejuvenated and the work of succession recommences.

The pertinent facts of succession into areas occupied by this association hav alredy been stated in connection with the different associations, but will be summed up here from the aspen standpoint. The great part of the area now occupied by the aspen association was formerly pine land. That it will again be pine, providing no serious accidents occur, is evident from the following pertinent facts. Scattered here and there in the aspens are seeding trees of pine, particularly *Pinus resinosa*, while in the aspens themselves are many seedlings of pines—*Pinus resinosa* and *Pinus strobus*—of different stages in development but all vigorous in appearance, as shown in Plate 19. The number is sufficiently great to produce a fair stand of pine as soon as the young trees can grow, provided fire is kept out. The great quantity of *Pteris aquilina* would point towards a tendency for the aspens to be succeded by oak woods such as is the case in many places in Michigan, Illinois, and Wisconsin. Oaks are represented in the region by several matur trees and numbers of seedlings, occuring isolated from one another and nowhere giving present indication of assuming the character of an association. Where oaks are present they are not infrequently associated with pine seedlings. Furthermore the region is nearly at the northern limit of the genus *Quercus*, so taken all in all it appears

*Weigle, W. G. & Frothingham, E. H. The Aspens: Their Growth and Management. U. S. Dept. of Agr. Forest Service, Bull. 93, May 1911.

that the oaks in this region merely indicate a step in succession between aspen and pine which is better seen in regions farther south. There need be no such step in the genetic series in this region but its presence indicates rather definitely that a given station is tending toward pine rather than hardwood.

In the case of the average hardwood burn, the aspen association is quite frequently present but represented by a large percentage of *Betula alba papyrifera* and the large numbers of seedling and small hardwoods readily indicate the approaching hardwood. In case the burn is so severe as to burn out the humus, the normal aspen association takes possession and the station tends towards pine rather than hardwood.

In the burns and clearing in the *Picea-Abies* association, the bramble association usually obtains dominance and by its shade precludes the aspen association. Occasionally it may obtain a weak start but the ground is so suitable for the spruce and balsam that they very quickly succede it.

A cleared bog normally returns to bog without any intervening step but a burnt bog may or may not do so. If the burn is not too severe there is a brief dominance of fireweed followed by the bog species. In case of a severe burn, as shown in Plates 20a, 20b and 21a, the fireweed is followed by aspens—especially *Populus tremuloides*—and the aspen association obtains a temporary dominance on account of the lack of available food materials for bog species in the soil rather than for any other reason. The soil is wet, too much so for good development of aspen, and the growth is continually killed off at the margins by the invading bog species, which in a few years regain their dominance. With a rising of the water table the bogs can easily invade the territory now occupied by the aspens but with a lowering of the water table the aspens cannot invade the bog, on account of the dense shade, until the bog trees die and fall.

Some of the land east of Pellston shown in Pl. 16b, which was very severely burnt a few years ago and has since come up to aspen, particularly *Populus grandidentata* with a mixtur of *Prunus pennsylvanica* and a ground cover of *Poa pratensis, Diervilla lonicera, Pteris aquilina,* and *Gnaphalium decurrens,* with hardly another species of plant for miles, shows indications of becoming a "Pine barren" by the occasional presence of seedlings of *Pinus banksiana.* These seedlings are healthy and appear to be developing quite rapidly. In case this association does become developt before white or red pine should get in, it would be an extension of the pine barren country into this region where, upon the advent of the lumberman, it was not present.

List of the Species of the Aspen Association:

A. Trees.

DOMINANT SPECIES.

Populus tremuloides
Populus grandidentata.
Betula alba papyrifera. } 96%.
Prunus pennsylvanica.

SECONDARY SPECIES.

Populus balsamifera. *Prunus serotina.*

RELIC SPECIES.

(A few surviving giants over 100 feet high, standing high above all other vegetation.)

Pinus resinosa. *Pinus strobus.*

INVADING SPECIES.

Quercus rubra.
(Few fair sized but mostly small and more or less depauperate.)
Acer rubrum.
(Few old and several small trees, but mostly near the shore or in low ground.)
Acer saccharum (seedlings).
Pinus strobus (numerous seedlings).
Pinus resinosa (numerous seedlings and young trees).
Pinus banksiana (seedlings and small trees east of Pellston).
Fagus grandifolia (seedlings, mostly more or less depauperate).
Tilia americana (seedlings, few).

B. Shrubs.

DOMINANT SPECIES.

Diervilla lonicera (very abundant and with *Pteris* carpeting the ground).
Rhus glabra.

SECONDARY SPECIES.

Gaylussacia baccata.
Vaccinium pennsylvanicum.
Vaccinium canadense.
Salix rostrata.
Salix lucida.
Viburnum acerifolium.
Prunus virginiana.
Rosa blanda.
Rhus toxicodendron.
Amelanchier canadensis.
Cornus circinata.
Rubus spp.
Salix discolor.
Corylus americana.

RELIC SPECIES.

Rubus idaeus aculeatissimus.
Epigaea repens.
Chamaedaphne calyculata (in wet ground).
Arctostaphylos uva-ursi (left after fire).
Nemopanthes mucronata.
Rubus alleghaniensis.
Gaultheria procumbens (common, a relic of pines).

C. Herbs.

DOMINANT SPECIES.

Pteris aquilina (very abundant and frequently the only species in addition to the trees, especially in cleared land; an indication of a tendency towards the development of oak).

SECONDARY SPECIES.

Panicum xanthophysum.
Danthonia spicata.
Anaphalis margaritacea.
Gnaphalium decurrens.
Lactuca canadensis.
Aralia hispida.
Solidago canadensis.
Panicum depauperatum.
Aster azureus.
Poa pratensis (usually scattering but sometimes forming a light sod).
Agropyrum repens.
Agropyrum repens f. glaucum.
Apocynum androsaemifolium.
Cyperus spp.
Cyperus rivularis.
Agrostis hiemalis.
*Agrostis alba**
Carex umbellata.
Carex festucacea.
Asclepias syriaca.
Asclepias phytolaccoides.
Erigeron ramosus.
Lycopodium complanatum.
Hieracium venosum.
Hieracium scabrum.
Aster laevis.
Convolvulus spithamaeus.
Viola arenaria (rare).
Arabis glabra.
Melampyrum lineare.
Aristida sp.
Polygonum cilinode.
Cirsium arvense.
Fragaria virginiana.
Verbascum thapsus.
*Rumex acetosella**
Smilacina stellata.
*Phleum pretense**
*Lepidium apetalum**
*Lepidium virginianum**
Apocynum cannabinum.
Cladonia rangiferina.
Antennaria spp.
Physalis grandiflora (Loew).
Lycopodium tristachyum.
Solidago hispida.

*An asterisk indicates species which are ubiquitous.

RELIC SPECIES.

Pedicularis canadensis.
Epilobium angustifolium.
Erigeron canadensis.
Smilacina trifolia (in tree-remains after fire).
Osmunda cinnamomea.
Smilacina racemosa.
Monotropa uniflora.

SUMMARY.

1. The Douglas Lake region is an area of low, sandy ground in the middle western part of Cheboygan county and the middle eastern part of Emmet county, Michigan. This report is based on that part of the area within five to eight miles in all directions from Douglas Lake.

2. The region lies within the transition belt between the northeastern conifer and the deciduous forest provinces, within an area of little competition between them, in a climate favorable to tree growth.

3. The region has been repeatedly glaciated. The surface soil is sandy virtually thruout except for the clayey area northwest of Burt Lake.

4. The region contains 32 plant associations, representing two plant provinces; the northeastern conifer and the deciduous forest.

5. A study of the successions between the different plant associations leads to a very satisfactory understanding of the plant dynamics.

6. The fundamental starting point for genetic series is the waters of the different lakes of the region. The lines of succession commence with open water and procede thru stages of progressivly increasing dryness and progressivly increasing humification, reaching the ultimate climax in the Beech-Maple association. The intermediate steps group themselves along five genetic lines.

7. Commencing with the lake one genetic series extends from aquatic algae thru associations living in shallower and shallower water to the edge of the water. The swamp series whose associations replace open water by a swamp area, normally of but brief duration. The bog series, which converts open water into a plant covered area and procedes thru associations of higher growth-form in richer soil until the tract is tree covered. The sandy-land series, whose associations advance in growth-form and live in progressivly richer soil. The burn series brought about by accidents interrupting the normal genetic series resulting in rejuvenescence.

8. Under present climatic and soil conditions there are three quasi-climatic associations which should occupy virtually the entire area: on the bog land, the *Thuja* association; on the dry sandy land, the pine association; and on the richer sandy or clayey land, the Beech-Maple association. As the result of burns, lumbering, etc., a great deal of the land is occupied by the aspen association, tending, however, to be replaced by the normal associations for the kind of soil.

9. Between the three quasi-climatic associations mentioned above there is nearly a stable equilibrium with the following tendencies with obtain either way. The drying of bog land permits pine or hardwood invasion and the humification of pine land permits hardwood invasion.

EXPLANATION OF PLATES.

ANNOTATED LIST OF SPECIES.[1]

Thallophyta (Algae and Fungi).

Chara sp. 190.[2] Besides characterizing an association it occurs in all the strictly aquatic associations.

Cladonia rangiferina 274. Sandy ground in the aspen assoc.

Cladonia spp. In the aspen assoc. and in the cedar bogs. Other lichens were observed but were not determined.

Bryophyta (Liverworts and Mosses).

Marchantia polymorpha L. 289. Abundant in places in the cedar bogs.

Sphagnum spp. Very abundant in the *Chamaedaphne* assoc. and occurring also in tamarack and cedar bogs.

Polytrichum sp. 294. Fairly abundant in cedar bogs.

Other species of mosses were observed but were not determined.

Pteridophyta (Ferns and Fern Allies).

Polypodiaceae (Fern Family.)

Phegopteris dryopteris (L) Fée. Oak Fern. 74, 151. Locally abundant in cedar bogs.

Adiantum pedatum L. Maidenhair. 478. In maple woods along Burt Lake.

Pteris aquilina L. Bracken. 5. Very abundant in the aspen assoc. and of quite general distribution in other associations which permit it sufficient light.

Asplenium filix-femina (L.) Bernh. Lady Fern. 56, 469. Local in maple woods, but especially in cedar bogs.

Aspidium thelypteris (L.) Sw. Occurs in boggy ground associations but especially in the *Iris* assoc.

Aspidium noveboracense (L.) Sw. 83, 451. Scarce, occuring in cedar bogs.

Aspidium goldianum Hook. Collected by Prof. F. Smith and Mr. Quick, Aug. 18, 1911 in beech-maple woods.

Aspidium spinulosum (O. F. Müller) Sw. 163, 167. In the beech-maple assoc.

Cystopteris bulbifera (L.) Bernh. 472. Local in hardwoods along west shore of Burt Lake.

Cystopteris fragilis (L.) Bernh. 452. Local in hardwoods along Burt Lake.

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[1]The nomenclatur of Gray's Manual, 7th edition, the latest taxonomic work, is used throughout this list.
[2]Collection numbers of the season of 1911.

Onoclea sensibilis L. Sensitive Fern. 60, 164. In boggy ground associations.

Onoclea struthiopteris (L.) Hoffm. 476. One station near a spring at the edge of a cut-away part of the hardwoods along Burt Lake.

Osmundaceae (Flowering Fern Family).

Osmunda regalis L. Royal Fern. 43. In boggy places, not common.

Osmunda claytoniana L. Local in hardwoods along Burt Lake.

Osmunda cinnamomea L. Cinnamon Fern. 41. Locally in cedar bogs and in boggy places in the hardwoods.

Ophioglossaceae (Adder's Tongue Family).

Botrychium ramosum (Roth) Aschers. Collected by Mr. Quick in beech-maple woods.

Botrychium ternatum intermedium D. C. Eaton. Collected by and in herbarium of Mr. Quick, from a drying bog. (347) Collected by H. B. Baker near the edge of hardwoods.*

Botrychium ternatum rutaefolium (A. Br.) D. C. Eaton. In herbarium of Mr. Quick, from beech-maple woods.

Botrychium virginianum (L.) Sw. 88, 281. Not uncommon in both hardwoods and cedar bogs.

Equisetaceae (Horsetail Family).

Equisetum litorale Kühlewein. 368. Cedar bog.

Equisetum scirpoides Michx. In a cedar bog.

Equisetum laevigatum A. Br. In a *Calamagrostis* meadow.

Equisetum fluviatile L. Pipes. Found by Mr. Quick in 1911.

Equisetum hiemale robustum (A. Br.) A. A. Eaton. Found by Mr. Quick, July 18, 1911.

Equisetum hiemale intermedium. A. A. Eaton. Collected by Miss Margaretta Packer in 1911.

Lycopodiaceae (Club Moss Family).

Lycopodium annotinum L. 400. In beech-maple assoc.

Lycopodium clavatum L. 85. Local in cedar bog.

Lycopodium complanatum L. 93, 271. Frequent in the aspen assoc. as a relic of former pines.

Lycopodium tristachyum Pursh. In the sandy soil of the aspens.

SPERMATOPHYTA (Seed-Plants.)

Taxaceae (Yew Family).

Taxus canadensis Marsh. American Yew, Ground Hemlock. 110. Fairly abundant in cedar bogs, but occurring also in the hardwoods.

Pinaceae (Pine Family).

Pinus strobus L. White Pine. 42, 159. Formerly dominating an association, now a few trees remain as relics and seedlings indicate that it may again take possession of the dry, sandy soil.

*These collections show the presence of this species in N. Michigan. Gray's Manual, 7th edition, page 49.

Pinus banksiana Lamb. Jack Pine. 142. A very few old trees in the aspens and seedlings invading in the aspens in the area east of Pellston.
Pinus resinosa Ait. Norway or Red Pine. 19, 20. Formerly a dominant tree in the pine association, now represented in the aspens by both old trees and seedlings, becoming more abundant.
Larix laricina (DuRoi) Koch. Tamarack. 36. A dominant tree in the *Larix* association and an abundant tree in cedar bogs where it is a relic.
Picea canadensis (Mill.) BSP. White Spruce. 76. A dominant tree in the *Picea-Abies* association, but occurs sparingly also in cedar bogs.
Picea mariana (Mill.) BSP. Black Spruce. 45. Abundant in tamarack and cedar bogs.
Picea mariana forma **brevifolia** (Peck) Gates comb. nov. Bog Spruce. 46. A xerophytic modification occuring in *Chamaedaphne* bogs, as at Silver Lake.
Abies balsamea (L.) Mill. Balsam. 62, 104, 203. A dominant species in the *Picea-Abies* association, but occurring in hardwoods sparingly and in cedar bogs quite commonly.
Tsuga canadensis (L.) Carr. Hemlock. 106, 173, 398. Frequent in hardwoods but not uncommon in cedar bogs.
Thuja occidentalis L. White Cedar, Arbor Vitae. 123. The dominant tree in cedar bogs, a ready invader of lower associations, and to a moderate degree a relic in genetically higher associations.
Juniperus communis L. Common Juniper. Found by Mr. Loew in 1910, and Mr. Quick in 1911.

Typhaceae (Cat-tail Family).

Typha latifolia L. 235. Occurring in marshy and boggy places but is not common.

Sparganiaceae (Bur-reed Family).

Sparganium simplex Huds. 519. A dominant species in the *Menyanthes-Sagittaria* association as it occurs in Bessey Creek.

Naiadaceae (Pondweed Family).

Potamogeton natans L. 255, 449. In Douglas and Burt Lakes.
Potamogeton heterophyllus Schreb. Two forms of this species f. *myriophyllus* (Robbins) Morong and f. *maximus* Morong, collected in Douglas Lake by Miss M. Packer and Miss A. K. Dietz.
Potamogeton lucens L. 261, 264. In Douglas and Burt Lakes in the *Potamogeton* association.
Potamogeton richardsonii (Benn.) Rydb. 187, 258, 265?, 450, 507. In the *Potamogeton* association in Douglas and Burt Lakes.
Potamogeton zosterifolius Schumacher. 254, 509. *Potamogeton* association.
Potamogeton strictifolius Benn. Collected by Miss M. Packer and Miss A. K. Dietz, 1911.
Potamogeton pectinatus L. 262. *Potamogeton* association.
Potamogeton filiformis Pers. Collected in Douglas Lake by Miss Margaretta Packer and Miss Ada K. Dietz in 1911.
Potamogeton spp. In *Potamogeton* association.
Najas flexilis (Willd.) Rostk. & Schmidt. 263. *Potamogeton* association in Douglas Lake.

Alismaceae (Water-plantain Family).

Sagittaria latifolia Willd. Arrow Leaf. 423, 510. Besides dominating an association, it occurs sparingly in other aquatic associations.

Hydrocharitaceae (Frog's Bit Family.)

Elodea canadensis Michx. Water-Weed. 188. Frequent in nearly all of the aquatic associations in Douglas Lake.

Vallisneria spiralis L. Eel Grass. 257. Rare in some of the aquatic associations in Douglas Lake.

Poaceae (Grass Family) (Gramineae in Gray's Manual).

Panicum depauperatum Muhl. 49, 269, 279. Secondary species in aspens.

Panicum xanthophysum Gray. 3, 96, 267. An abundant secondary species in the aspens.

Panicum boreale Nash. Collected by Dr. H. A. Gleason.

Panicum sp. A secondary species in the *Myrica* association.

Panicum spp.

Echinochloa crusgalli (L.) Beauv. 500. Very sparingly in cultivated ground or along roadsides.

Setaria viridis (L.) Beauv. Foxtail Grass. 383. As a fireweed on burnt-over hardwood land.

Hierochloe odorata (L.) Wahlenb. Vanilla Grass. 191. Locally distributed in a *Myrica* bog.

Muhlenbergia sp. 521. In a willow thicket along Maple River.

Phleum pratense L. Timothy. 8. In the aspens, especially near dwellings.

Agrostis alba L. Red Top. 245. Frequent in the aspens.

Agrostis hyemalis (Walt.) BSP. Hair Grass. 391. As a fireweed of local distribution in the aspens.

Calamagrostis canadensis (Michx.) Beauv. Blue-joint Grass. 224, 388. In one station forming a small meadow, but otherwise uncommon.

Calamagrostis inexpansa Gray. 225. Rare, occurring with the preceding.

Cinna arundinacea L. Wood Reed Grass. 216. Uncommon in associations along the west shore of Douglas Lake.

Avena sativa L. (Oats). 244. Rare, in the aspens along roads.

Danthonia spicata (L.) Beauv. Oat Grass. 1. Widespread in its distribution in the aspens.

Spartina michauxiana Hitchc. Slough Grass. 154. On the fringing dune in places around Douglas Lake and growing in several of the semi-aquatic associations in wet sandy soil.

Phragmites communis Trin. (Reed). 220. Uncommon, occurring along the west shore of Douglas Lake and with Typha in cut-over cedar bogs.

Poa pratensis L. Blue Grass. 7, 143, 157. Widely distributed in the aspens and occasional in the roads thru cedar bogs.

Poa sp. 196. Occasional in the beech-maple woods.

Glyceria nervata (Willd.) Trin. Fowl Meadow Grass. 118. Uncommon, occurring in a cedar bog and in willow thickets.

Glyceria borealis (Nash) Batchelder. 387. In water in several aquatic associations but particularly abundant in the Bessey Creek region.

Bromus ciliatus L. Brome Grass. 520. Uncommon, in a willow thicket along Maple River.

Agropyron repens (L.) Beauv. Couch Grass. 137. Occasional in the aspens.
Agropyron repens f. **glaucum**. 138, 236. On a railroad grade and in aspens.
Agropyron sp. 522. In a willow thicket along Maple River.
Elymus canadensis L. Wild Rye. 446. On the fringing dune along Douglas Lake.
Hystrix patula Moench. Bottle-brush Grass. 477. Local in a beech-maple woods along Burt Lake.

Cyperaceae (Sedge Family).

Cyperus rivularis Kunth. 270. Rare, in the aspens.
Cyperus sp.
Dulichium arundinaceum (L.) Britton. 223. Uncommon, occurring in a few of the marsh associations along the west shore of Douglas Lake.
Eleocharis palustris vigens Bailey. 256. Besides dominating an aquatic association it occurs in several of the aquatic and semiaquatic associations in standing water.
Eleocharis sp. Collected by Miss M. Packer and Miss A. K. Dietz.
Scirpus americanus Pers. 3-angled Bulrush. 182. Dominates a semiaquatic association and occurs in several aquatic and semiaquatic associations.
Scirpus validus Vahl. Great Bulrush. 189, 504. Dominates an aquatic association and occurs in several others. Abundant, especially at the mouth of Bessey Creek.
Scirpus cyperinus pelius Fernald. 21?, 242, 516. In moist ground associations especially where the original ground cover has been disturbed.
Eriophorum viridi-carinatum (Engelm.) Fernald. Cotton Grass. 112. Occurs sparingly in openings in cedar bogs.
Eriophorum virginicum L. 436. In *Chamaedaphne* and cedar bogs.
Cladium mariscoides (Muhl.) Torr. Twig Rush. 213. Infrequent, dominating an association along the west shore of Douglas Lake.
Carex festucacea Schkuhr. Sedge. 2,276. Fairly common in the aspens.
Carex bebbii Olney. 306. Cedar bog.
Carex crinita Lam. 127. Cedar bog.
Carex crinita subsp? 367. In a developing cedar bog.
Carex lenticularis Michx. 211. In the *Myrica* association in a bog.
Carex aurea Nutt. 353. Cedar bog.
Carex pauciflora Lightf. 37. Sparingly in a *Chamaedaphne* bog (Silver Lake)
Carex leptalea Wahlenb. 288. Cedar bog.
Carex umbellata Schkuhr. Rare in the aspens.
Carex laxiflora Lam. In beech-maple woods, along Burt Lake.
Carex oederi pumila (Cosson & Germain) Fernald. 215. Infrequent, in Cladium assoc.
Carex filiformis L. 393. Dominating an aquatic bog association and occurring in a few other aquatic associations.
Carex hystericina Muhl. 119. Cedar bog.
Carex retrorsa Schwein. 58. Cedar bog.
Carex lupulina Muhl. 405. In boggy ground in beech-maple woods.
Carex intumescens Rudge. 149, 386. In cedar bogs and in hardwoods.
Carex rostrata Stokes. 442. In willow thickets and in cedar bogs.

Carex spp. Several unidentified species were collected in cedar bogs, beech-maple woods and other places, but the Carex-flora had passed its season before the author arrived.

Araceae (Arum Family).

Arisaema triphyllum (L.) Schott. 339. Sparingly in cedar bogs and in hardwoods.

Juncaceae (Rush Family).

Juncus bufonius L. In a road thru a cedar bog.
Juncus tenuis Willd. 129. In roads thru hardwoods and in bramble patches.
Juncus balticus littoralis Engelm. Dominating a shore association and occurring in a few other shore associations, not common.
Juncus effusus L. 309. In a road thru a cedar bog.
Juncus spp.

Liliaceae (Lily Family).

Uvularia grandiflora J. E. Smith. Bellwort. 460. In hardwoods along Burt (Lake).
Allium tricoccum Aiton. Onion. 475. In hardwoods along Burt Lake.
Lilium philadelphicum andinum (Nutt.) Ker. Wild Orange-red Lily. 87. In cedar bogs, not frequent.
Lilium (intermediate between *canadense* and *superbum*). 120. In cedar bogs, but not very common.
Clintonia borealis (Aiton) Raf. 63, 177, 322. In all the tree associations but most characteristic of the cedar bogs and the beech-maple woods.
Smilacina racemosa (L.) Desf. False Solomon's Seal. 315, 448. Most characteristic of the beech-maple woods, tho occurring in other of the tree associations.
Smilacina stellata (L.) Desf. False Solomon's Seal. 345. Common, in the aspens and less so in the willow thickets.
Smilacina trifolia (L.) Desf. 3-leaved False Solomon's Seal. 34, 64. In *Chamaedaphne* and cedar bogs, not very common.
Maianthemum canadense Desf. 65, 176, 316. Very characteristic of the beech-maple woods, tho abundant also in the cedar bogs.
Streptopus amplexifolius (L.) DC. Twisted-Stalk. 125, 150, 374. Characteristic in the undergrowth of cedar bogs.
Streptopus roseus Michaux. In beech-maple woods.
Streptopus longipes Fernald. 317, 459. In beech-maple woods.
Polygonatum biflorum (Walt.) Ell. Solomon's Seal. In beech-maple woods.
Polygonatum commutatum (R. & S.) Dietr. Great Solomon's Seal. 179, 372. A characteristic species in the beech-maple woods.
Medeola virginiana L. Indian Cucumber-Root. 293, 319. Occurring in cedar bogs but more characteristic in beech-maple woods.
Trillium grandiflorum (Michx.) Salisb. Trillium. 55, 314, 401. Occurring in cedar bogs but more characteristic in beech-maple woods.

Iridaceae (Iris Family).

Iris versicolor L. Blue Flag. 214, 246. Besides characterizing an association it occurs in many of the associations of moist or wet ground, persisting as a relic even in thickets and under trees.

Orchidaceae (Orchis Family).

Cypripedium parviflorum Salisb. Smaller Yellow Lady's Slipper. 79, 116. In cedar bogs, not common.

Cypripedium parviflorum pubescens (Willd.) Knight. Larger Yellow Lady's Slipper. In cedar bogs with the preceding, not common.

Cypripedium hirsutum Mill. Showy Lady's Slipper. 89. Cedar bogs, not common.

Cypripedium acaule Ait. Stemless Lady's Slipper. 445.1. Four plants found in a *Chamaedaphne* bog in recently burnt-over ground.

Habenaria flava (L.) Gray. Occurring in the tamarack Association, rare.

Habenaria hyperborea (L.) R. Br. 70, 369. Fairly abundant in cedar bogs.

Habenaria clavellata (Michx.) Spreng. Found by Mr. Quick, July 10, 1911.

Habenaria obtusata (Pursh) Richards. 375. In a cedar bog, not common.

Habenaria orbiculata (Pursh.) Torr. 266. Two plants found in the *Picea-Abies* association, by Miss Arbuthnot.

Habenaria blephariglottis (Willd.) Torr. White Fringed Orchid. 26. About a dozen plants found in a *Chamaedaphne* bog around Silver Lake.

Habenaria psycodes (L.) Sw. 75. A few plants found in a cedar bog.

Calopogon pulchellus (Sw.) R. Br. 38. In a *Chamaedaphne* bog at Silver Lake.

Spiranthes romanzoffiana Cham. (Ladies' Tresses). Miss Anna Arbuthnot, Aug. 4, 1911.

Epipactis repens ophioides (Fernald)A. A. Eaton. Miss Arbuthnot, Aug. 4, 1911.

Epipactis decipiens (Hook.) Ames. Rattlesnake Plantain. 406. A few plants in beech-maple woods north of Douglas Lake.

Corallorrhiza maculata Raf. Coral Root. 202. A few plants in the beech-maple woods along the north shore of Douglas Lake.

Listera convallarioides (Sw.) Torr. Twayblade. Found by Mr. Loew in 1910.

Salicaceae (Willow Family).

Salix lucida Muhl. Shining Willow. 86. One of the commonest species in the willow thickets and invading many of the wet ground associations.

Salix serissima (Bailey) Fernald. Autumn Willow. 205. Two bushes at the limit of ice work on Douglas Lake west of Ingleside.

Salix longifolia Muhl. Sand Bar Willow. 158. Along the shore of Douglas Lake, not abundant.

Salix cordata Muhl. 111. Along a road thru a cedar bog.

Salix balsamifera Barratt. Found by Mr. Loew in 1910.

Salix glaucophylla Bebb. 342. On the beach of Douglas Lake.

Salix pedicellaris Pursh. 392. A characteristic shrub in the low bog thickets and readily invading the *Carex filiformis* mat.

Salix discolor Muhl. Glaucous Willow. 280. In willow thickets, fairly common.

Salix discolor x rostrata. 404. Bordering Douglas Lake and occasional in the beech-maple woods.

Salix rostrata Richards. 11. A common willow in the thickets and in the aspens, but also occurring in cedar bogs and beech-maple woods.

Salix candida Flügge. Hoary Willow. 192. One of the dominant species in the *Myrica* bog association, but not abundant.

Salix spp.

Populus tremuloides Michx. Small-toothed Aspen. 14, 30. One of the most abundant species in the region, dominating in the aspen associa- and occurring in many of the other associations, especially on burnt land, and remaining as a relic to a very limited extent.

Populus grandidentata Michx. Large-toothed Aspen. 13, 31. The same status as *P. tremuloides* but has a tendency to occur in drier ground.

Populus balsamifera L. Balsam Popular. 134. Along the shores of Douglas Lake, not common.

Populus deltoides Marsh. Cottonwood. Two or three trees near the ruins of a hotel on Colonial Point, Burt Lake. Also planted in Pellston.

Myricaceae (Sweet Gale Family).

Myrica gale L. Sweet Gale. 61, 141, 252. Dominating a bog association and remaining as a relic in willow thickets and cedar bogs.

Myrica asplenifolia L. Sweet Fern. 53. Of local and limited occurrence in pine land.

Betulaceae (Birch Family).

Corylus americana Walt. Hazelnut. In the aspens.

Corylus rostrata Ait. Beakt Hazelnut. Collected in previous seasons.

Ostrya virginiana (Mill.) K. Koch. Ironwood. 444. Sparingly in beech-maple woods.

Betula lenta L. Sweet Birch. 464. A few trees in the hardwoods in the gorge.

Betula lutea Michx. f. Yellow Birch. 50, 107, 297, 378. Most abundant in the hardwoods and *Picea-Abies*, and readily invading other associations.

Betula pumila L. Low Birch. Found by Mr. Loew in 1910.

Betula alba papyrifera (Marsh.) Spach. White Birch. 9, 28, 343. An abundant species in the aspens, but occurring also in several other associations.

Alnus incana (L.) Moench. Speckled Alder. 72, 209, 253, 421. Quite common in bog thickets and along roads thru cedar bogs.

Fagaceae (Beech Family).

Fagus grandifolia Ehrh. Beech. 12, 170, 313, 321. A dominant species in the beech-maple woods and occurring in a few other associations as seedlings and young trees.

Quercus rubra L. Red Oak. 15. A few old trees occur in the beech-maple woods and seedlings, sprouts and young trees occur in a few other associations, especially the aspens.

Urticaceae (Nettle Family).

Ulmus fulva Michx. Slippery Elm. 227. In willow thickets.

Ulmus americana L. American Elm. 474. A few old trees in the beech-maple woods along Burt Lake and seedlings in the aspen and in the thicket associations.

Pilea pumila (L.) A. Gray. Clearweed. 455. In the beech-maple woods along Burt Lake.

Santalaceae (Sandalwood Family).

Comandra umbellata (L.) Nutt. Bastard Toad-flax. Obtained in previous years.
Comandra livida Richards. Rare, sandy shore of Burt Lake.

Polygonaceae (Buckwheat Family).

Rumex crispus L. Curled Dock. 250. Scarce, in the *Iris* Association.
Rumex acetosella L. Sheep Sorrel. 32, 243. As a fireweed in burnt land.
Polygonum aviculare L. 439. In a roadway.
Polygonum amphibium L. 221, 232. Not common, occurring in moist ground in thickets, *Calamagrostis* meadow and once as a fireweed.
Polygonum acre HBK. Water Smartweed. 456. Along a road thru a beech-maple woods, rare.
Polygonum persicaria L. Lady's Thumb. Collected by Mr. Loew in 1910.
Polygonum hydropiperoides Michx. Mild Water Pepper. 518. Banks of Maple River, at the edge of the willow thickets.
Polygonum cilinode Michx. Bindweed. 208. Occasional in thickets, willow, aspen, *Myrica* and brambles.
Fagopyrum esculentum Moench. Buckwheat. 437. In an abandoned field.

Chenopodiaceae (Goosefoot Family).

Chenopodium capitatum (L.) Asch. Strawberry Blite. 384, 513. A fireweed of limited distribution, occurring also in fields.
Chenopodium hybridum L. Maple-leaved Goosefoot. 380. Fireweed.
Chenopodium album L. Lamb's Quarters. 381. Fireweed of limited distribution.
Chenopodium sp. 517. In an abandoned field.

Amaranthaceae (Amaranth Family).

Amaranthus retroflexus L. Pigweed. 382. An uncommon fireweed.
Amaranthus blitoides Wats. 427. In a sandy abandoned field.

Caryophyllaceae (Pink Family).

Stellaria media (L.) Cyrill. Chickweed. 416. In a road thru a beech-maple woods near Vincent Lake.
Cerastium vulgatum L. Mouse-ear Chickweed. 287. In a road thru a cedar bog.
Agrostemma githago L. Corn Cockle. 433. In an abandoned rye field.
Silene antirrhina L. Sleepy Catchfly. Collected by Mr. Loew.
Silene noctiflora L. Night flowering Catchfly. 54. One plant found in a cedar bog along a roadway.
Saponaria officinalis L. Soapwort. 409. In a fence corner near an abandoned farm house.

Portulacaceae (Purslane Family).

Portulaca oleracea L. Common Purslane. 514. In an abandoned field.

Ceratophyllaceae (Hornwort Family).

Ceratophyllum demersum L. 508. In the *Potamogeton* association in Douglas L.

Nymphaeaceae (Water Lily Family).

Nymphaea americana (Provancher) Miller & Standley. Yellow Water Lily. A dominant species in the *Castalia-Nymphaea* association and occurs in some of the other aquatic associations as a relic or an invader.

Castalia odorata (Ait.) Woodville and Wood. Sweet-scented Water Lily. 506. A dominant species in the *Castalia-Nymphaea* association in Douglas Lake.

Castalia tuberosa (Paine) Greene. 505. A dominant species in the *Castalia-Nymphaea* association, not common.

Ranunculaceae (Crowfoot Family).

Ranunculus purshii Richards. Collected by Miss M. Packer and Miss A. K. Dietz. Muddy banks of Bessey Creek.

Ranunculus abortivus L. Small-flowered Crowfoot. Collected by Mr. Loew in 1910.

Ranunculus septentrionalis Poir. Swamp Crowfoot. 330. In the bramble association following a burn in the *Picea-Abies* association.

Ranunculus recurvatus Poir. Hookt Crowfoot. 98. In a cedar bog.

Ranunculus hispidus Michx. 302; 335. In brambles and in a cedar bog.

Ranunculus pennsylvanicus L. f. Bristly Crowfoot. 512. In a willow thicket.

Ranunculus acris L. Tall Buttercup. 358. In a road thru a cedar bog.

Ranunculus sp. 413. In beech-maple woods.

Thalictrum dioicum L. Early Meadow Rue. Found by Mr. Loew in 1910.

Thalictrum dasycarpum Fisch. & Lall. Meadow Rue. 210, 231. In willow and *Myrica* thickets, not common.

Hepatica triloba Chaix. Hepatica. 169. In beech-maple woods.

Anemone cylindrica A. Gray. Found by Mr. Quick, July 18, 1911.

Anemone virginiana L. Found by Mr. Quick, July 18, 1911.

Anemone canadensis L. Anemone. 84. At the edge of a cedar bog.

Clematis virginiana L. Clematis. 479. Willow thickets along Maple River.

Caltha palustris L. Marsh Marigold. 296. In the gorge, not common, and in cedar bogs.

Coptis trifolia (L.) Salisb. Goldthread. 284. An abundant species in cedar bogs.

Aquilegia canadensis L. Columbine. 101. Sparingly in cedar bogs and in beech-maple woods.

Actaea rubra (Ait.) Willd. Red Baneberry. 97. Cedar bogs.

Actaea alba (L.) Mill. White Baneberry. 415. In beech-maple woods along Burt Lake.

Berberidaceae (Barberry Family).

Caulophyllum thalictroides (L.) Michx. Blue Cohosh. 471. A few plants in the beech-maple woods along Burt Lake.

Podophyllum peltatum L. May Apple. Found in 1911 by Mr. Quick.

Fumariaceae (Fumitory Family).

Corydalis sempervirens (L.) Pers. Collected by Mr. Loew in 1910.

Cruciferae (Mustard Family).

Lepidium virginicum L. Peppergrass. 10. In the aspens.
Lepidium apetalum Willd. In the aspens.
Capsella bursa-pastoris (L.) Medic. Shepherd's Purse. 360. In an abandoned field.
Brassica arvensis (L.) Ktze. Mustard. 489. Rare, along roads.
Sisymbrium altissimum L. Tumble Mustard. Collected by Mr. Loew in 1910.
Radicula palustris hispida (Desv.) Robinson. Marsh Cress. 233. In the *Iris* association and in willow thickets.
Cardamine pennsylvanica Muhl. Collected along Bessey Creek by Miss M. Packer and Miss A. K. Dietz.
Arabis glabra (L.) Bernh. Tower Mustard. 248, 325. In the aspens.

Sarraceniaceae (Pitcher-plant Family).

Sarracenia purpurea L. Pitcher Plant. 23. *Chamaedaphne* bogs.

Droseraceae (Sundew Family).

Drosera rotundifolia L. Round-leaved Sundew. 286. In cedar bogs.

Crassulaceae (Orpine Family).

Sedum acre L. Mossy Stonecrop. Found by botany class in 1911.

Saxifragaceae (Saxifrage Family).

Mitella nuda L. Bishop's Cap. 91, 285. Common in cedar bogs, tho also occurring in beech-maple woods.
Ribes cynosbati L. Prickly Gooseberry. 301. A dominant species in the bramble association and occurring also in willow thickets and cedar bogs.
Ribes floridum L'Her. Wild Black Currant. Loew 1910.
Ribes hudsonianum Richards. 295. Rare, in a cedar bog.
Ribes lacustre (Pers.) Poir. Swamp Black Currant. Loew 1910.
Ribes prostratum L'Her. Skunk Currant. 430. Willow thicket at the edge of a bog near Vincent Lake.
Ribes triste albinervium (Michx.) Fernald. Swamp Red Currant. 282. In cedar bogs.

Hamamelidaceae (Witch-Hazel Family).

Hamamelis virginiana L. Witch Hazel. Found by Mr. Loew 1910.

Rosaceae (Rose Family.)

Spiraea salicifolia L. 394. In willow thickets and invading in *Chamaedaphne* bogs.
Pyrus arbutifolia (L.) L. f. Chokeberry. 422. A dominant species in certain bog thickets.
Pyrus arbutifolia atropurpurea (Britton) Robinson. 29. With the above but more frequent as an invader in the *Chamaedaphne* association.
Pyrus melanocarpa (Michx.) Willd. 300. In cedar bogs.
Pyrus americana (Marsh.) DC. Mountain Ash. 443. Generally common in the *Picea-Abies* association and present in cedar bogs.

Amelanchier canadensis (L.) Medic. Service Berry. 200. As underbrush in tree associations, particularly the aspens.

Amelanchier spicata (Lam.) C. Koch. Found by Mr. Loew 1910.

Crataegus sp. Rare.

Fragaria virginiana Duchesne. Strawberry. 105. Occurring in several associations, particularly the cedar bogs and the aspens.

Potentilla arguta Pursh. Found by Mr. Loew in 1910.

Potentilla monspeliensis L. 238. On the fringing dune in a willow thicket.

Potentilla palustris (L.) Scop. Marsh Five-Finger. 222. In the *Cladium* and *Carex filiformis* associations and also in a few other bog associations.

Potentilla anserina L. Silver Weed. 239. Dominating a beach association and occurring in a few other associations on the beach of Douglas Lake.

Potentilla canadensis L. Local in a tamarack bog.

Geum macrophyllum Willd. Avens. A few in a tamarack bog, n. w. of Ingleside.

Geum rivale L. Water or Purple Avens. Found by Mr. Loew in 1910 and Mr. Quick July 4, 1911.

Geum sp. 453. In the beech-maple woods, along Burt Lake.

Geum triflorum Pursh. 59, 333. In cedar bogs and in the bramble association.

Rubus idaeus aculeatissimus (C. A. Mey.) Regel & Tiling. Wild Red Raspberry. 135. Dominant in the bramble association and occurring in several others, particularly the aspens.

Rubus triflorus Richards. Dwarf Raspberry. 109. Abundant in bogs, particularly cedar bogs.

Rubus allegheniensis Porter. Blackberry. Dominant in the brambles and occurring more or less commonly in the aspens.

Dalibarda repens L. Found by Mr. Loew in 1910.

Agrimonia gryposepala Wallr. Agrimony. 299. In a roadway thru a cedar bog.

Rosa blanda Ait. Wild Rose. 251. In the aspens along the shore of Douglas Lake.

Rosa carolina L. In willow thickets bordering bogs.

Rosa sp. In the aspens.

Prunus serotina Ehrh. Black Cherry. Occurring in the aspens and in beech-maple woods, not common.

Prunus virginiana L. Choke Cherry. 148, 336. Occurring in the aspens, willow thickets and in the bramble association.

Prunus pennsylvanica L. f. Pin Cherry. 33, 247. A dominant species in the aspens and occurring in several other associations especially on burnt-over land.

Prunus pumila L. Sand Cherry. A few shrubs along the beach of Douglas Lake.

Leguminosae (Pulse or Legume Family).

Trifolium pratense L. Red Clover. 361. In fields.

Trifolium repens L. White Clover. 431. In willow thickets and in roadways in cedar bogs.

Lathyrus palustris L. Vetchling. Found by Mr. Loew in 1910.

Apios tuberosa Moench. Groundnut. Found by Mr. Loew in 1910.

Geraniaceae (Geranium Family).

Geranium robertianum L. Herb Robert. 414. In beech-maple woods. rare.

Polygalaceae (Milkwort Family).

Polygala paucifolia Willd. Fringed Polygala. Found by Mr. Loew in 1910 and by Mr. Quick in 1911.

Euphorbiaceae (Spurge Family).

Euphorbia cyparissias L. Cypress Spurge. 445. Along a road thru a beech-maple woods.

Euphorbia maculata L. Milk Purslane. Found by Mr. Loew in 1910.

Anacardiaceae (Cashew Family).

Rhus typhina L. Staghorn Sumac. 6. In the aspens.

Rhus glabra L. Smooth Sumac. 275. A dominant shrub in the aspens. Many of the plants are inclined to be somewhat pubescent but never so much so as in *Rhus typhina*.

Rhus toxicodendron L. Poison Ivy. 346. On willow ridges, in the aspens, and occasionally in the beech-maple woods.

Aquifoliaceae (Holly Family).

Ilex verticillata (L.) A. Gray. 51. In cedar and *Chamaedaphne* bogs.

Nemopanthus mucronata (L.) Trel. Mountain Holly. 35, 390, 403. Occurring mostly in bogs, but also in the aspens and in beech-maple woods.

Celastraceae (Staff Tree Family).

Celastrus scandens L. Climbing Bitter-sweet. 204. In beech-maple woods.

Aceraceae (Maple Family).

Acer pennsylvanicum L. Striped Maple. 57, 131. Occurring on the borders of cedar bogs and beech-maple woods.

Acer spicatum Lam. Mountain Maple. Most abundant in the *Picea-Abies* association but common in cedar and tamarack bogs and to a less extent in beech-maple woods.

Acer saccharum Marsh. Sugar Maple. 132, 178, 318, 320, 399. A dominant species in the beech-maple woods and occurring as invader in several other associations. One of the most abundant trees of the region.

Acer rubrum L. Red Maple. 4, 17, 186. A common species growing in most of the boggy ground associations, but also in the aspens and the beech-maple woods. Sometimes specimens (218) are very close to *Acer saccharinum* L., a more southern tree, but absence of fruit prevented certain identification.

Balsaminaceae (Touch-me-not Family).

Impatiens pallida Nutt. Pale Touch-me-not. 467. In small bottomland formed along the course of a streamlet in a beech-maple woods along Burt Lake.

Impatiens biflora Walt. Spotted Touch-me-not. In the *Picea-Abies* Association.

Rhamnaceae (Buckthorn Family).

Rhamnus alnifolia L'Her. 67. In cedar bogs.

Vitaceae (Grape Family).

Psedera quinquefolia (L.) Greene. Virginia Creeper. 493. Willow thicket, scarce.
Vitis vulpina L. Grape. Grapevine Point, Douglas Lake.

Tiliaceae (Linden Family).

Tilia americana L. Basswood. 165, 310. A dominant species in the beech-maple woods, tho not plentifully represented in the region.

Malvaceae (Mallow Family).

Malva rotundifolia L. Common Mallow. 357. Along a road near farm houses.

Hypericaceae (St. John's-Wort Family).

Hypericum canadense L. St. John's Wort. 441. In a road thru a willow thicket near Ingleside.
Hypericum virginicum L. Marsh St. John's Wort. In marsh associations, as the *Iris*, *Cladium* and *Calamagrostis* associations, not common.

Violaceae (Violet Family).

Viola papilionacea Pursh. In beech-maple woods.
Viola renifolia Gray. In cedar bogs.
Viola blanda Willd. Sweet White Violet. 162. Lowland in beech-maple woods.
Viola scabriuscula Schwein. Smooth Yellow Violet. 466. In beech-maple woods.
Viola arenaria DC. 396. A few patches found in the aspens northeast of Burt Lake.
Viola sp. 412. In beech-maple woods.

Lythraceae (Loosestrife Family).

Decodon verticillatus (L.) Ell. Water Willow. 420. In an alder thicket near Vincent Lake.

Onagraceae (Evening Primrose Family).

Ludvigia palustris (L.) Ell. Collected by Miss M. Packer and Miss A. K. Dietz, 1911.
Epilobium angustifolium L. Fireweed. 503. The commonest fireweed thruout the region.
Epilobium molle Torr. Found by Mr. Loew in 1910.
Epilobium adenocaulon Haussk (?). 168. In a clearing in hardwoods.
Epilobium coloratum Muhl. Willow-Herb. 389. In the bramble and the *Chamaedaphne* associations.
Epilobium sp. 290. In a cedar bog.

Œnothera biennis L. Evening Primrose. 487. Near a farm house.
Circaea lutetiana L. Enchanter's Nightshade. 411. In beech-maple woods.
Circaea intermedia Ehrh. 463. In beech-maple woods along Burt Lake.
Circaea alpina L. 338. In the *Picea-Abies* association in the gorge.

Haloragidaceae (Water Milfoil Family).

Myriophyllum spicatum L. 185, 260. In nearly all of the strictly aquatic associations in Douglas and Burt Lakes.
Proserpinaca palustris amblyogona Fernald. Mermaid-weed. Found by Mr. Quick, Aug. 15, 1911.

Araliaceae (Ginseng Family).

Aralia racemosa L. Spikenard. 130. In beech-maple woods.
Aralia hispida Vent. Bristly Sarsaparilla. 136, 312. In the aspen and fireweed associations, common.
Aralia nudicaulis L. Wild Sarsaparilla. 68, 115. Most common in beech-maple woods, tho very common in cedar bogs and in the *Picea-Abies* association.

Umbelliferae (Parsley Family).

Sanicula gregaria Bicknell. Black Snakeroot. 99. In cedar bogs.
Osmorhiza claytoni (Michx.) Clark. Sweet Cicely. 417. In a beech-maple woods near Vincent Lake.
Osmorhiza longistylis (Torr.) DC. Found by Mr. Loew in 1910.
Cicuta maculata L. Water Hemlock. Found by Mr. Loew in 1910.
Sium cicutaefolium Schrank. Water Parsnip. Found by Mr. Loew in 1910.
Pastinaca sativa L. Parsnip. 494. Along a road near farm houses.
Oxypolis rigidior (L.) Coulter and Rose. Cowbane. 237. In a Typha swamp and also in a few marsh associations, not common.

Cornaceae (Dogwood Family).

Cornus canadensis L. Dwarf Dogwood. 47, 102. Very common in cedar bogs, but also rather plentiful in the aspens and the beech-maple woods.
Cornus circinata L'Her. Round-leaved Dogwood. 272, 340. Most common in the aspens, but also occurs in other associations, as tamarack, beech-maple and brambles.
Cornus stolonifera Michx. Red-osier Dogwood. 73, 207. In willow thickets and invading several herbaceous associations.
Cornus alternifolia L. f. Found in 1909.
Cornus sp. 354. In a cedar bog.

Ericaceae (Heath Family).

Chimaphila umbellata (L.) Nutt. Pipsissewa. 371. In beech-maple woods.
Moneses uniflora (L.) A. Gray. One-flowered Wintergreen. 103, 292. Local in a cedar bog.
Pyrola secunda L. Wintergreen. 90, 114, 174. Common in cedar and tamarack bogs and occasional in beech-maple woods.

Pyrola chlorantha Sw. In beech-maple woods.
Pyrola elliptica Nutt. Shin Leaf. 172, 457. In beech-maple woods.
Pyrola asarifolia Michx. 78, 152. In tamarack and cedar bogs.
Pyrola asarifolia incarnata (Fisch.) Fernald. Collected in a cedar bog, July 4, 1911, by Mr. B. E. Quick.
Monotropa uniflora L. Indian Pipe. 501. A few plants found in the aspens, growing on pineland.
Ledum groenlandicum Oeder. Labrador Tea. 77. In tamarack and cedar bogs.
Kalmia polifolia Wang. Pale Laurel. 44. In *Chamaedaphne* bogs.
Andromeda glaucophylla Link. Bog Rosemary. 25. In *Chamaedaphne* bogs.
Chamaedaphne calyculata (L.) Moench. Leather Leaf. 27, 395. Dominating a bog association, invading the *Carex filiformis* association, remaining as a relic in cedar bogs and occasionally occurring in the aspens.
Epigaea repens L. Trailing Arbutus. 113. Occurring sparingly in cedar bogs, the *Picea-Abies* and aspen associations.
Gaultheria procumbens L. Wintergreen. In cedar bogs and in the aspens, a relic of pine dominance.
Arctostaphylos uva-ursi (L.) Spreng. Bearberry. 16. Representing the heath association by its occurrence in the aspens near the shore of Douglas Lake.
Chiogenes hispidula (L.) T. & G. Creeping Snowberry. 283. Fairly common in cedar bogs.
Gaylussacia baccata (Wang.) C. Koch. Huckleberry. 40. In the aspens, common.
Gaylussacia baccata f. glaucocarpa (Robinson) Mackenzie. At Silver Lake, in the *Chamaedaphne* association.
Vaccinium pennsylvanicum Lam. Blueberry. 18. Abundant in the aspens.
Vaccinium canadense Kalm. Velvet-leaf Blueberry. 39, 201. In beech-maple woods and in the *Chamaedaphne* and aspen associations.
Vaccinium vacillans Kalm. Low Late Blueberry. In a *Chamaedaphne* bog.
Vaccinium oxycoccus L. Small Cranberry. 24, 81. In *Chamaedaphne* and cedar bogs.

Primulaceae (Primrose Family).

Lysimachia terrestris (L.) BSP. Loosestrife. 217, 241. In the *Iris* and *Calamagrostis* as well as other marsh associations.
Lysimachia thyrsiflora L. Tufted Loosestrife. 229. In the *Calamagrostis* meadow and in willow thickets, not common.
Trientalis americana (Pers.) Pursh. Star Flower. 175. Common in the beech-maple woods but occurring also in cedar bogs and the *Picea-Abies* assoc.

Oleaceae (Olive Family).

Fraxinus americana L. White Ash. 197. In the beech-maple woods, not common.
Fraxinus nigra Marsh. Black Ash. 69, 100. Most common in tamarack and cedar bogs, but also in beech-maple woods and invading thickets.

Gentianaceae (Gentian Family).

Gentiana linearis latifolia Gray. Found by Miss Hattie Kimball, Aug 24, 1911.
Halenia deflexa (Sm.) Griseb. Spurred Gentian. Found by Mr. Loew in 1910.
Menyanthes trifoliata L. Buckbean. 22. Dominating a bog association and occurring in the *Chamaedaphne* association.

Apocynaceae (Dogbane Family).

Apocynum androsaemifolium L. Spreading Dogbane. 324. In the aspens and beech-maple woods.
Apocynum cannabinum L. Indian Hemp. 502. Along the shore of Douglas Lake and the aspens.

Asclepiadaceae (Milkweed Family).

Asclepias incarnata L. Swamp Milkweed. 228. In willow thickets and in marsh associations, as *Iris* and *Cladium*.
Asclepias syriaca L. Common Milkweed. 94. In the aspens.
Asclepias phytolaccoides Pursh. Poke Milkweed. 95. In aspens.

Convolvulaceae (Morning Glory Family).

Convolvulus spithamaeus L. 326. Quite common in the aspens.

Boraginaceae (Borage Family).

Cynoglossum officinale L. Hound's Tung. 432. In a road thru a beech-maple woods.
Lappula deflexa (Wahlenb.) Garcke. Stickseed. 418. Local in a clearing in a bog near Vincent Lake.
Lappula redowskii occidentalis (Wats.) Rydb. 490. Railway Ballast and in the aspens, not common.

Verbenaceae (Vervain Family).

Verbena bracteosa Michx. 425. In an abandoned grain field near Vincent Lake.

Labiatae (Mint Family).

Scutellaria lateriflora L. Mad-dog Skullcap. Found by Mr. Quick, Aug. 4, 1911.
Scutellaria galericulata L. Skullcap. 155. In the *Iris* and a few other marsh associations.
Marrubium vulgare L. Common Horehound. 481. In wet places along two roads, east of Douglas Lake.
Nepeta cataria L. Catnip. 429. Along a road thru a beech-maple woods.
Prunella vulgaris L. Heal-all. 126. In roads thru cedar bogs and beech-maple woods, usually in the *Iris* association.
Leonurus cardiaca L. Motherwort. 483. Along a road near farm houses.
Blephilia hirsuta (Pursh) Benth. Wood Mint. 410. In beech-maple wood along north shore of Douglas Lake.

Lycopus americanus Muhl. Water Horehound. 180. In the *Iris* and several other marsh associations.
Lycopus sp.
Mentha spicata L. Spearmint. 408, 499. Along a road.
Mentha piperita L. Peppermint. In a roadside ditch.
Mentha arvensis canadensis (L.) Briquet. 332, 424. In a number of wet ground associations of herbaceous plants and persisting into willow thickets.

Solanaceae (Nightshade Family).

Solanum nigrum L. Common Nightshade. 419, 458. Edges of cedar bogs and along roads thru beech-maple woods, not common.
Physalis grandiflora Hook. White Ground Cherry. 331. Collected by Mr. Fred A. Loew in the aspens. (3 plants).
Physalis heterophylla ambigua (Gray) Rydb. Ground Cherry. 426. In an abandoned grain field near Vincent Lake.

Scrophulariaceae (Figwort Family).

Verbascum thapsus L. (Mullen). 278. Fairly common in aspens and brambles.
Linaria vulgaris Hill. Butter and Eggs. 486. Railroad ballast.
Mimulus ringens L. Monkey Flower. 234. Willow thickets along Maple River and in the *Iris* association.
Mimulus glabratus jamesii (T. & G.) A. Gray. 80. In the *Menyanthes* and cedar bog associations.
Veronica anagallis-aquatica L. Water Speedwell. 291. In streams thru a cedar bog.
Veronica scutellata L. Marsh Speedwell. Found by Mr. Loew in 1910, and Miss Packer in 1911.
Melampyrum lineare Lam. Cow Wheat. 407. In the aspens.
Pedicularis canadensis L. Lousewort. 327. In the aspens along the gorge.

Lentibulariaceae (Bladderwort Family).

Utricularia cornuta Michx. 181. A few plants in the *Eleocharis* and *Scirpus americanus* associations along the shore of Douglas Lake.

Plantaginaceae (Plantain Family).

Plantago major L. Common Plantain. 359. In fields.
Plantago lanceolata L. Rib Grass. 495. Along a few roads.

Rubiaceae (Madder Family).

Galium circaezans Michx. Wild Liquorice. Found by Mr. Loew in 1910.
Galium lanceolatum Torr. Found by Mr. Loew in 1910.
Galium boreale L. Northern Bedstraw. 323. In a *Myrica* thicket.
Galium triflorum Michx. Sweet-scented Bedstraw. 108, 166. In woods, beech-maple, *Picea-Abies*, cedar and tamarack bogs.
Mitchella repens L. Partridge Berry. 82, 171. In beech-maple, *Picea-Abies* woods and cedar bogs, not very common.
Cephalanthus occidentalis L. Buttonbush. Found by Mr. Loew in 1910.

Caprifoliaceae (Honeysuckle Family).

Diervilla lonicera Mill. Bush Honeysuckle. 48, 121. One of the most abundant species in the aspens, but occurring also in the beech-maple woods and in cedar bogs, where the leaves are quite a little modified.
Lonicera canadensis Marsh. American Fly Honeysuckle. 355, 465. In beech-maple woods.
Lonicera oblongifolia (Goldie) Hook. Swamp Fly Honeysuckle. In tamarack and cedar bogs.
Lonicera hirsuta Eaton. Hairy Honeysuckle. Found by Mr. Loew in 1910.
Lonicera glaucescens Rydb. 117. In beech-maple woods and cedar bogs.
Lonicera dioica L. 344. On a sandy ridge in a willow thicket.
Linnaea borealis americana (Forbes) Rehder. Twin-Flower. 124. Common in cedar bogs.
Viburnum opulus americanum (Mill.) Ait. High-bush Cranberry. 144. In a willow thicket along Maple River.
Viburnum acerifolium L. Arrowwood. 447. In the aspens.
Viburnum cassinoides L. 147, 160, 199. In willow thickets and on the borders of beech-maple woods.
Viburnum lentago L. Found in 1910 by Mr. Loew.
Sambucus canadensis L. Common Elder. 139. In willow thickets along Maple river and in the brambles to a very limited extent.
Sambucus racemosus L. Red berried Elder. 133. In willow thickets, along the borders of hardwoods and in the brambles.

Campanulaceae (Bluebell Family).

Canpanula rotundifolia velutina DC. Cited in Beal's "Michigan Flora" from "sand hills along Burt Lake, E. J. Hill," but was not discovered.
Canpanula aparinoides Pursh. Marsh Bellflower. 249, 511. In the *Iris* and *Calamagrostis* as well as in other marsh associations and occasionally in willow thickets.
Canpanula uliginosa Rydb. Collected in 1911, by Dr. H. A. Gleason and Mr. B. E. Quick from a *Myrica* bog thicket.

Lobeliaceae (Lobelia Family).

Lobelia cardinalis L. Cardinal Flower. 156. In the *Iris* and *Cladium* as well as other marsh associations around beach pools, and persisting into thickets.
Lobelia siphilitica L. Great Lobelia. Found by Mr. Loew in 1910.
Lobelia kalmii L. Found by Mr. Loew in 1910, Mr. Quick, July 18, 1911.

Compositae (Composit Family).

Eupatorium purpureum L. Joe-Pye Weed. 226. Dominant in the *Iris* and occurring in many other associations of wet ground, including thickets and cedar bogs.
Eupatorium perfoliatum L. Boneset. 328. Dominating in the *Iris* but occurring in many of the other wet ground associations as well as the brambles, common.
Solidago uliginosa Nutt. Goldenrod. 480. In tamarack and cedar bogs, not common.

Solidago hispida Muhl. Collected in the aspens by Mr. B. E. Quick, Aug. 22, 1911.

Solidago rugosa Mill. In the brambles following burning in the *Picea-Abies* association in the gorge.

Solidago canadensis L. Goldenrod. 311, 515. A fireweed occurring also in associations of dry sandy land.

Solidago graminifolia (L.) Salisb. In *Myrica* and willow thickets and in a few of the beach associations (*Scirpus americanus* and *Potentilla anserina*).

Aster macrophyllus L. In beech-maple woods and occasionally in cedar bogs.

Aster novae-angliae L. As a fireweed and in willow thickets.

Aster azureus Lindl. 1. In the aspens.

Aster laevis L. In the aspens, common.

Aster junceus Ait. Bog Aster. In tamarack bogs, northwest of Ingleside.

Erigeron pulchellus Michx. Robin's Plantain. 370. In burnt cedar bog land. Rare.

Erigeron annuus (L.) Pers. Daisy Fleabane. 366. In a field.

Erigeron ramosus (Walt.) BSP. Daisy Fleabane. 268. In the aspens.

Erigeron canadensis L. Horseweed. 350, 435, 482. A fireweed, occurring also in associations of dry sandy land.

Antennaria plantaginifolia (L.) Richards. Everlasting. Bordering a beech-maple woods.

Antennaria sp. 273, 376. Scattered patches in the aspens.

Anaphalis margaritacea (L.) B. & H. Pearly Everlasting. 52, 308, 329. In the brambles and aspens and occasionally in cedar bogs.

Gnaphalium decurrens Ives. Everlasting. 397. A common species in the aspen-pine barren land east of Pellston.

Gnaphalium uliginosum L. Low Cudweed. 440. Along a road thru a willow thicket in bog land near Ingleside.

Silphium laciniatum L. Compass Plant. A few plants in a garden near Burt Lake (H. A. Gleason and C. L. Hill).

Silphium terebinthinaceum Jacq. Prairie Dock. A few plants in the same garden. (Gleason and Hill).

Iva xanthifolia Nutt. Abundant around the shacks of a former lumber camp a little way north of Levering.

Ambrosia artemisiifolia L. Ragweed. 434. In an abandoned grain field.

Rudbeckia hirta L. Black-eyed Susan. 365. At the edge of a rye field.

Helianthus sp. In the aspens.

Bidens vulgata Greene. Stick-Tight. A fireweed in wet ground.

Bidens connata Muhl. Found by Mr. Loew in 1910.

Achillea millefolium L. Yarrow. 298. Along a road thru a cedar bog.

Anthemis cotula L. Dog Fennel. 364. In a pasture near Burt Lake.

Chrysanthemum leucanthemum L. Ox-eye Daisy. 66, 363. In a grain field and in a cedar bog, rare.

Chrysanthemum balsamita tanacetoides Boiss. Mint Geranium. 356, 498. Along roadsides near farm houses.

Artemisia ludoviciana Nutt. 484. Roadside near a farm house.

Erechtites hieracifolia (L.) Raf. Fireweed. A common fireweed, but very local in its distribution in this region.

Arctium minus Bernh. Burdock. 428. In a road thru a beech-maple wood near Ingleside.

Cirsium lanceolatum (L.) Hill. Bull Thistle. Found by Mr. Loew in 1910.

Cirsium muticum Michx. Swamp Thistle. 334. In the bramble association, in *Picea-Abies* land in the gorge.
Cirsium arvense (L.) Scop. Canada Thistle. 140. In the aspens, not common.
Cichorium intybus L. Chicory. 496. Along a road.
Taraxacum officinale Weber. Dandelion. 497. Along a road.
Sonchus asper (L.) Hill. Spiny-leaved Sow Thistle. 362. In a pasture.
Lactuca scariola integrata Gren. & Godr. Prickly Lettuce. 438. Fields.
Lactuca canadensis L. Wild Lettuce. 145. In the aspens.
Lactuca pulchella (Pursh) DC. Blue Lettuce. Found by Dr. Gleason in 1911.
Lactuca spicata (Lam.) Hitchc. Tall Blue Lettuce. In low ground in beech-maple woods.
Lactuca spicata integrifolia (A. Gray) Britton. 454. In a beech-maple woods along Burt Lake.
Prenanthes alba L. White Lettuce. Found by Mr. Quick in 1911.
Hieracium pratense Tausch. King Devil. 341. Collected in a beech-maple woods by Mr. F. E. Loew.
Hieracium venosum L. Rattlesnake Weed. 277, 348. A common species in the aspens.
Hieracium scabrum Michx. 349. In the aspens.
Hieracium canadense Michx. Found by Mr. Loew in 1910.

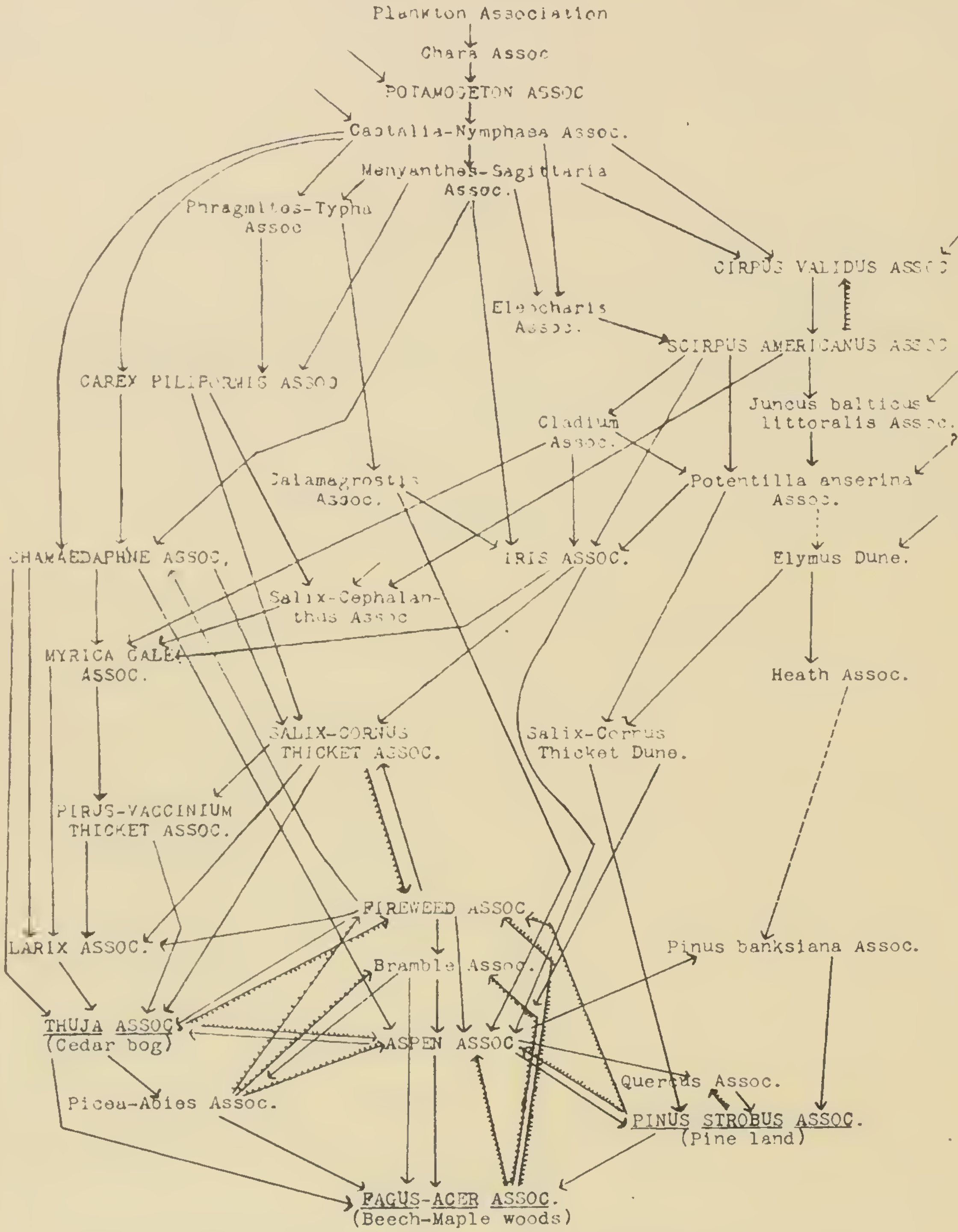
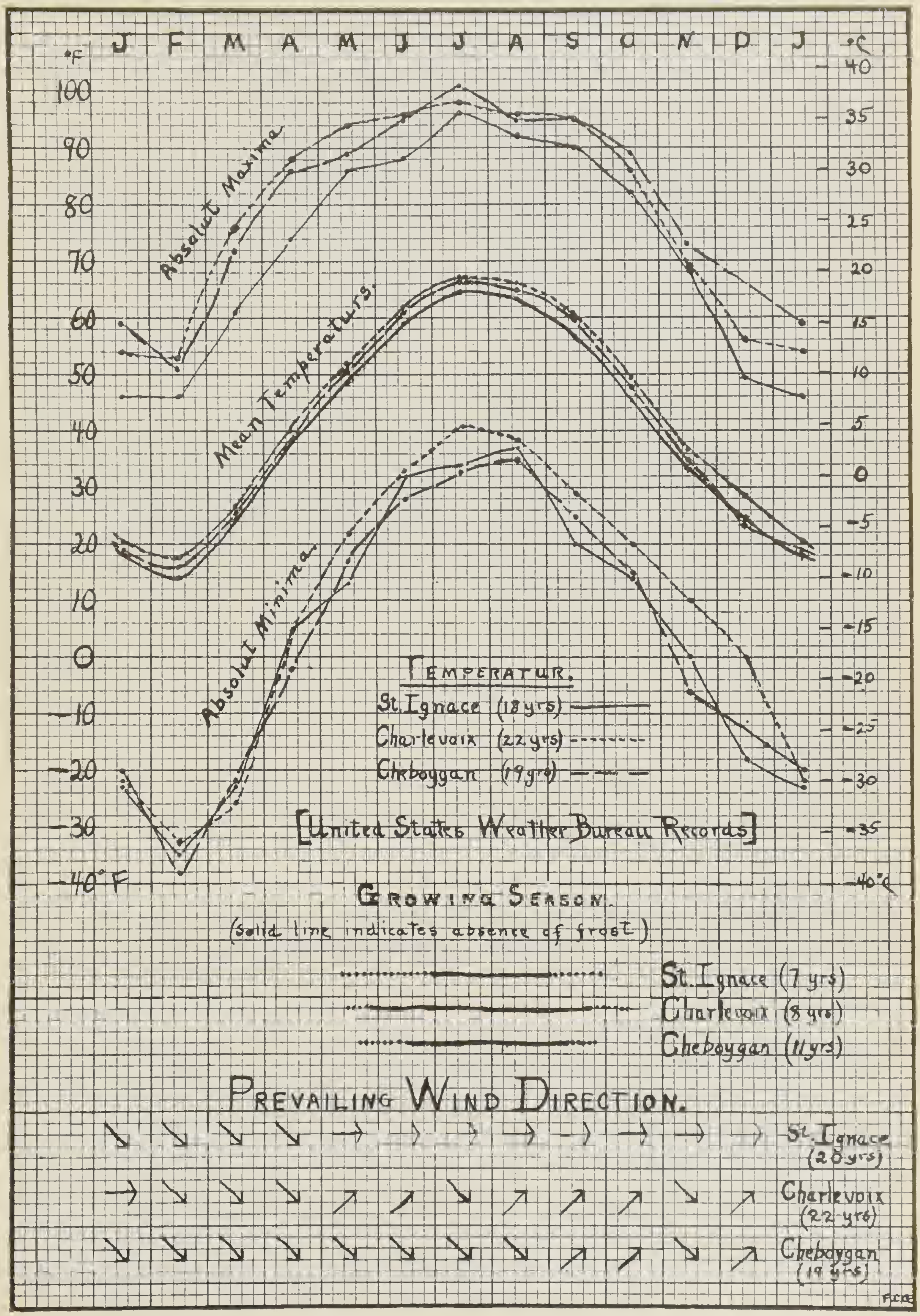
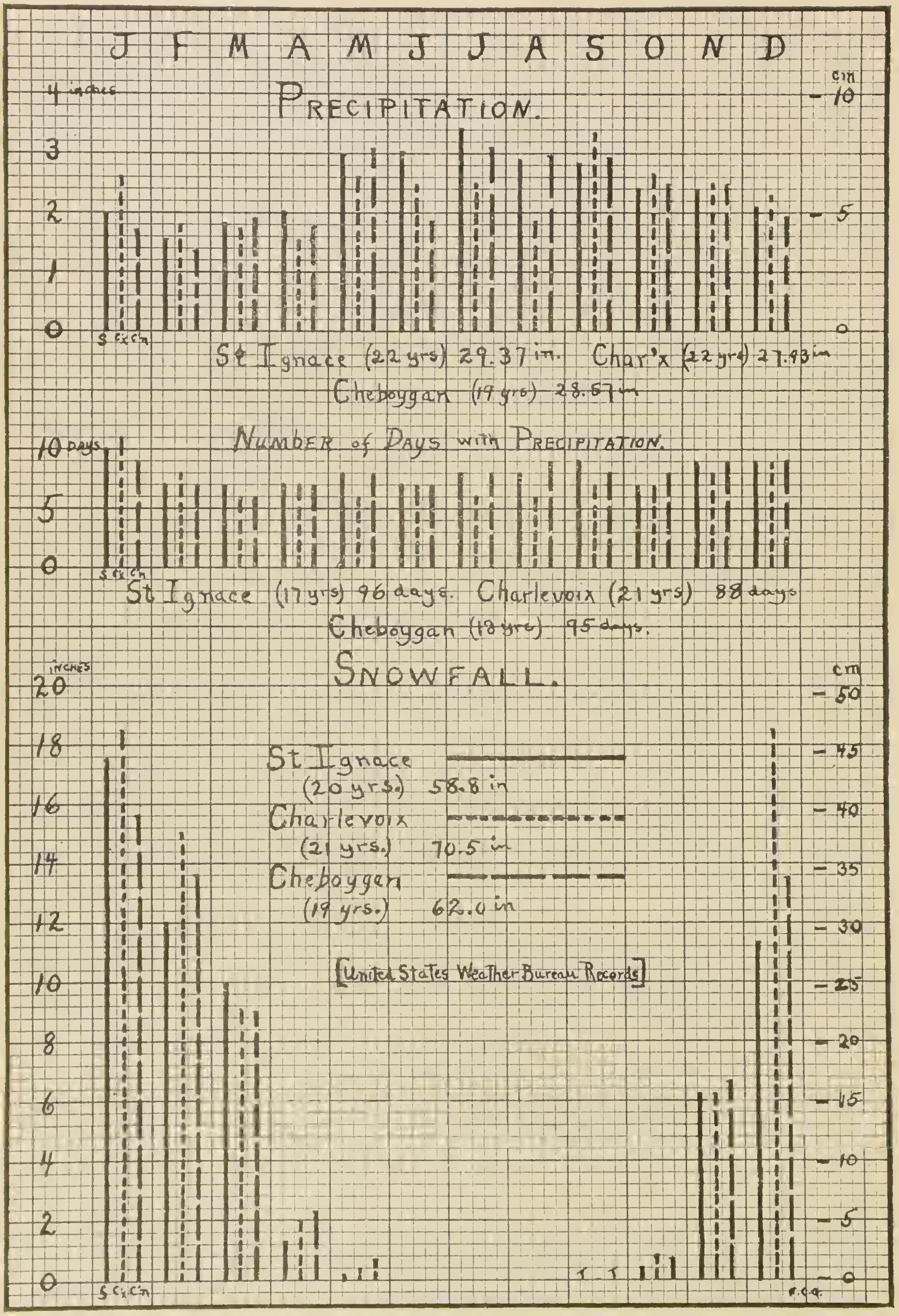


Diagram showing the successions exhibited between the plant associations in the Douglas Lake Region, Emmet & Cheboygan Counties, Michigan. 1911.

——— primary successions. ‸‸‸‸‸‸‸ secondary successions due to clearing, burning or other disturbing factors.

Capital letters denote the important associations. The climatic associations occupying the most prominent soil types are underlined. (FCG)


J F M A M J J A S O N D J
°F
°C
100
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40° F
40
35
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
−35
−40°C
Absolut Maxima
Mean Temperaturs.
Absolut Minima.
Temperatur.
St. Ignace (18 yrs)
Charlevoix (22 yrs)
Cheboygan (19 yrs)
[United States Weather Bureau Records]
Growing Season.
(solid line indicates absence of frost)
St. Ignace (7 yrs)
Charlevoix (8 yrs)
Cheboygan (11 yrs)
Prevailing Wind Direction.
St. Ignace (20 yrs)
Charlevoix (22 yrs)
Cheboygan (19 yrs)


J F M A M J J A S O N D
PRECIPITATION.
4 inches
cm
St Ignace (22 yrs) 29.37 in. Char'x (22 yrs) 27.93 in
Cheboygan (19 yrs) 28.57 in
NUMBER of DAYS with PRECIPITATION.
10 DAYS
St Ignace (17 yrs) 96 days. Charlevoix (21 yrs) 88 days
Cheboygan (18 yrs) 95 days.
SNOWFALL.
INCHES
St Ignace (20 yrs.) 58.8 in
Charlevoix (21 yrs.) 70.5 in
Cheboygan (19 yrs.) 62.0 in
[United States Weather Bureau Records]

SOME CONSIDERATIONS CONCERNING THE PLACE AND ORIGIN OF LAVA RESERVOIRS.

W. H. HOBBS.

The ideas which are generally held concerning the origin of lava have all gone out from the idea of a liquid interior to the earth. It has, however, been shown in recent years that the earth cannot have a fluid interior, but on the other hand must be as rigid as a ball of glass of the same size. Within the earth the temperatures of the rock would easily melt it under surface conditions, but the pressure from the superincumbent load elevates the point of fusion and so keeps the rock rigid, or as we might say, "solid" though realizing that the condition may in many respects be quite unlike that of solid bodies at the surface of the earth. There must, however, be local, and probably temporary, reservoirs which supply the lava which exudes or is ejected from volcanoes. It is shown in the paper that the position of active volcanoes, particularly about the Pacific, suggests that the lava reservoirs which supply their lava have been due to local reliefs from pressure beneath arches of strong formations developed in the process of mountain making. The relative strengths of different sedimentary formations lead inevitably to the conclusion that the type of formation which thus fuses and produces lava, is what is known as shale or slate. Studies of the chemical composition of igneous rocks, which compositions are limited in range, support this view; and the study of the gases which are given off from lavas afford some further striking confirmations of the theory.

THE AGE OF THE KEWEENAWAN SERIES.

A. C. LANE.

Van Hise and Leith's monograph on Lake Superior includes a valuable chapter on the Keweenawan series, and shows that as between them and the Michigan survey there is now no essential difference in the recognition of the facts. It is fully recognized by all that, so far as the facts go, they do not definitely prove or disprove the Cambrian or Pre-Cambrian age of the Keweenawan series. They think the balance of probability to be in favor of the Pre-Cambrian, the writer, in favor of the Cambrian, largely because the Keweenawan is a formation of very rapidly formed rocks (sandstones, conglomerates and traps) immediately underlying the Upper Cambrian, and is the first volcanic epoch preceeding. As the decision of this question has some bearing on important questions of nomenclature, it is worth considering how it may finally be settled:

1. Though the Keweenawan, has a "largely subaerial formation is not likely to be particularly fossiliferous, yet intercalations of acqueous

fossiliferous strata may be found and fossils were reported by Walcott, at the Christmas meeting 1911, of the G. S. A., in probably Pre-Keweenawan rocks north of Lake Superior.

2. It may be possible in the marine Cambrian, not far from the Keweenawan region, to find such signs of contemporaneous volcanic activity as to be closely correlated with the Keweenawan. Daly thinks there are such.

SOME INTERESTING CHANGES IN THE OPTICAL PROPERTIES OF CRYSTALS WITH TEMPERATURE.

E. H. KRAUS AND L. J. YOUNGS.

By using the ordinary metal air-bath, which accompanies the Fuess axial angle apparatus, as an oil bath, the changes in the apparent angle of the optic axis of gypsum can be easily determined at various temperatures up to 132.5° C., when the section becomes opaque. The average of the determinations of the temperature of uniaxiality in oil is 89.67° C. The temperature for uniaxial conditions in air was found to be somewhat higher, namely 91.6° C. These observations were made with sodium light. These temperatures are all lower than those given by Des Cloizeaux and Tutton, but show that the early determination in 1826 by Mitscherlich ol 91.8° C. is substantially correct. Very recently Hutchinson and Tutton have given the temperature of uniaxiality in water as 91° C. for sodium light. The changes in the apparent angles in oil and air, the unequal changes in the position of the two axes, and the acute bisectrix, and the relation between the apparent angle in oil and the real angle where shown by a series of curves. (The paper is to be published in detail in German in the Neues Jahrbuch für Mineralogie, Geologie, etc.)

ADDITIONAL NOTES ON THE GEOLOGY OF THE DETROIT RIVER AREA.

THOMAS NATTRESS.

In [1]another place I have given the results of investigation in the Anderdon Beds on the Canadian side of the Detroit river. Let me now present the results obtained in investigating the same limestone beds in Wayne county.

Twenty-five cores were taken out in the Trenton-Sibley area, twenty of which penetrated the Anderdon beds. The other five were outside of the limestone deposits and south of these, and in each case revealed strata of the same character as are presented in the other cores taken and below the Anderdon limestone in these cores.

The Anderdon material is deposited in the same manner as at the Amherstburg quarry, in basin formation. Its relation to strata above and below is the same as on the Canadian side of the river: immediately below the Anderdon is a dolomitic limestone, resting upon dolomite, and outcropping outside the outer edge of the Anderdon; immediately overlying the Anderdon is the dolomitic limestone hitherto recognized as forming the base of the [2]Corniferous (Dundee), the Anderdon outcropping outside the outer edge of this deposit. Cross-section tests prove the basin formation throughout the Sibley area.

CERTAIN FEATURES OF THE ANDERDON LIMESTONE BEDS have been noted during this investigation that had not hitherto been remarked upon. One of these is the occurrence, down in the body of the Anderdon deposit, and at [3]more than one horizon, of irregular and roughened surfaces like the upper surface of the Anderdon beds in the Amherstburg quarry. An [4]interpretation has been put upon the roughened condition of this latter surface as pointing toward extensive erosion at the close of Anderdon time.

Another notable feature is this: whereas the Oriskany Sandstone has been identified by competent [5]authorities at the surface of the weathered Anderdon beds in the Amherstburg quarry, and at the surface (or a little below it) of the Anderdon beds as exposed in the old well-hole at the Sibley quarry; I have found the same silicated condition of the Anderdon limestone at two different horizons in the Anderdon beds. In the Sibley core numbered 17 of the survey of 1911, at 45′6″ in the core, down to 47′3″, there is heavy silication; and again at 59′6″ to 60′0″ there is the same heavy silication. The sand grains are unmistakably the same.

I have in a former paper, referred to already, advanced evidence to show that the Anderdon beds should be classed as Devonian. Always

[1]13th. Report of the Michigan Academy of Science, 1911,—"The Extent of the Anderdon Beds of Essex County, Ontario, and Their Place in the Geologic Column."

[2]Dundee, (Michigan;) Columbus, (Ohio;) Onondaga, (New York;) and Jeffersonville, (Indiana.)

[3]As in cores No. 10 and No. 12.

[4]Bull. Geol. Soc. Am., Vol. 19, 1907, p. 542,—"New Upper Siluric Fauna from Southern Michigan.—Anderdon Exposure."

[5]Amadeus W. Grabau, William H. Sherzer, and Clinton R. Stauffer (in correspondence.)

have I been referred to the Oriskany as marking the division between the two. It has interested me very greatly to note that the fossil-bed characteristic of the Anderdon limestone beds *lies between* these two sandstone deposits at the No. 17 location, at 52 ft. to 56 ft. in the core, —below the recognized Oriskany horizon at 45′6″ and above the lower deposit of the same sand grains at 59′6″. The drill penetrated a heavily silicated rock at about the same lower horizon in nearly every hole put down through the Anderdon at Sibley.

Without knowledge of this additional evidence on the part of the reviewer, there appears in the November, 1911, number of the American Journal of Science (and over the initials "C. S.") this review of the paper in which the former evidence was presented:—"This paper presents conclusive evidence that the Anderdon limestones are not Silurian in age and cannot be included in the Monroe series, but 'are of Devonian age.' The Anderdon limestone lies in a trough of Monroe strata, and is to be grouped with the Onondaga formation of Middle Devonian time."

In one core (No. 20), and in this one only, the characteristic Anderdon fossil bed begins at once at the top of the Anderdon; and in this core only was the material of the fossil-bed found to be heavily silicated. The location is at the south side of the limestone deposit. Across the limestone field from this, on the northward side, both the top of the Anderdon is heavily silicated and the base of the Dundee.

On the occurrence of the Anderdon limestones, it may be noted in passing that rock of the same quality and varied appearance outcrops along the Maitland river at Goderich, Ontario; in the neighborhood of Kincardine and Southampton, along Lake Huron north of Goderich; at Cargill and at St. Marys, following along the north side of an arm of the old Devonian sea; and in the Thames valley between Ingersoll and Woodstock, Ontario. It has been identified to the westward of the Columbus (Corniferous) outcrop on Marble Head, Ohio, also. The smaller Canadian islands in the west end of Lake Erie were also examined, but these show only dolomites and no trace of Anderdon. If the Anderdon beds outcrop in Lake Erie it will be along a line west of Pelee and Kellys islands and east of Put-in Bay, the Bass islands and Old Hen island.

A cross section of the Detroit river area from the Amherstburg quarry to the Sibley quarry, and including both of these, shows Anderdon and overlying Corniferous at each end of the section, with only the underlying dolomites over the middle distance. The direction of the cross section is NW. x 12° W.; the distance 35,700 feet; eastern end of the section 10,200 ft. east of east channel bank of Detroit river, and the western end 6,000 ft. west of west channel bank. The Silurian dolomite surface is anticlinal from the middle of the Anderdon field at either end, and over the whole Detroit river distance between. This anticline is succeeded at each end of the section by a minor syncline, the combined distance of which is less than half the total distance of the intervening anticline. In these synclinal basins the material of the Anderdon beds lies,—in immediate contact with the dolomitic limestone base of the Corniferous above it, and separated from the dolomites below by another dolomitic limestone that is richer in $CaCO_3$ than is the limestone at the base of the Corniferous.

This northward extension of the great Cincinnati uplift has been more emphatically anticlinal than it is now, up to the close of the Corniferous period. The evidence of this is perceptible at a glance at the cross-section map: the Devonian surface at the Wayne county end of the section stands 30 feet higher than the maximum elevation (560 A. T.) of Silurian dolomite, and 25 feet higher at the Essex county end of the section. Not only so but the Corniferous deposit is bowed up in the center at either end of the section, and crevassed over its central area at Sibley where the maximum of thrust has been exerted. It may be that the higher part of the anticline—across the Detroit river distance—stands at a lower elevation than it once did. The conclusion is the same in the one case as in the other—there is a relatively lower anticlinal structure now than there was at the close of the Silurian age.

As that Silurian surface is now, Grosse Isle, as traversed by this section at all events, reposes in a minor syncline of the greater anticline, on a surface [6]lower than the rock bottom of the two channels of Detroit river on either side of it, east and west; whilst the river, in its main channel, traverses the highest part of the anticline.

These are the ascertained elevations along the line of cross-section, from west to east, with distances between successive points for which the elevation is quoted (i. e., Elevation of Silurian dolomite surface as hitherto accepted):

1. The Sibley section, to about middle of the Trenton channel of Detroit river:

   508.8 ft., (900 ft.,) 503.2 ft., (1,200 ft.,) 489.6 ft., (2,200 ft.,) 519.0 ft., (1,600 ft.,) 538.0 ft., (2,000 ft.,) to 543.0;

2. The Grosse Isle section to Ballards Reef in main channel of Detroit river:

   543.0 ft., (2,600 ft.,) 532.0 ft., (6,000 ft.,) 528.0 ft., (4,200 ft.,) to 550.0;

3. The main Detroit river section, eastward from Ballards Reef:

   550.0 ft., (2,200 ft.,) 548.0 ft., (2,400 ft.,) to 560.0 ft.;

4. The Amherstburg quarry section, from the east side of Detroit river channel:

   560.0 ft., (5,800 ft.,) 515.1 ft., (2,100 ft.,) 482.0 ft., (1,400 ft.,) 542.6 ft., (1,000 ft.,) to 575.7.

Evidence of another section. In an investigation like this in which so much has continued in doubt, it would be manifestly unfair not to present every vestige of evidence that has direct bearing. Therefore let another cross-section be here introduced. This section, from a point on the new Livingstone Channel, northeasterly across Bois Blanc island to a point some 10,800 ft. distant, will serve to illustrate again the relationship of the Anderdon beds to the Sylvania Sandrock and all that lies between and above the Sylvania.

At a point in the new channel west of the south quarter of Bois Blanc there was found to be a light deposit of white sand resting upon bedrock. This was all scraped off by the dredges in cleaning up the

[6]River bottom elevations obtained from U. S. Government Detroit River Improvement Survey. Grosse Isle elevations furnished by Professor W. H. Sherzer, from Survey publications. Sibley and Amherstburg elevations obtained by the Solvay Process Company's Survey.

bottom preparatory to putting on the drills. There was no sandrock penetrated by the drills,—only dolomite at this point. The Detroit. Belle Isle and Windsor Ferry Company's wells show a surface extension of Sylvania over the south quarter of Bois Blanc. Dredging in the river channel east of the island showed a Sylvania surface extension over the immediately adjacent river bottom. Two farms lie adjacent, eastward, the Patton farm and the Elliott farm. On the Patton farm, under 40 ft. of drift and one foot of shale, there is a 20 ft. depth of Sylvania, described by the driller and by Ed. Patton as "10 ft. of loose white sand and 10 ft. of sand-rock." Below this 20 foot deposit the drill developed dolomite. South of this on the next farm, at [7]Elliotts Point, the drill was put down into the Sylvania some distance, under 44 ft. of drift, blue clay and a gravel bed next the rock, and 25 ft. of dolomite.

Some 7,500 ft. north-easterly from this is the Colwell Grove well reported upon in H. P. H. Brumell's [8]"Natural Gas and Petroleum in Ontario." This record shows 252 ft. of "limestone" next above 60 ft. of "sandstone." The well was put down in 1889, up to which time no fine distinction had as yet been made in the records between limestones and dolomites and the terms were used indiscriminately: whereas the "sandstone" was supposed then to be [9]Oriskany.

In the same immediate neighborhood with the Colwell Grove well is the No. 28 well of my survey of 1910. This shows about four feet of Anderdon limestone under 12 ft. of drift and over nine feet of transitional limestone resting upon dolomite. Neighboring tests, wells No. 29, 27, 30, and 1 of 1910 survey, show similar deposits of Anderdon.

Thus the relationship of the Anderdon limestone beds toward the Sylvania Sandrock is established at this one locality, on comparison of the Colwell Grove well and the 1910 No. 28,—with 252 ft. of "limestone" (Brumell,) less four feet of Anderdon limestone, or 248 ft. of dolomitic limestone and dolomites between the bottom of the Anderdon and the top of the Sylvania.

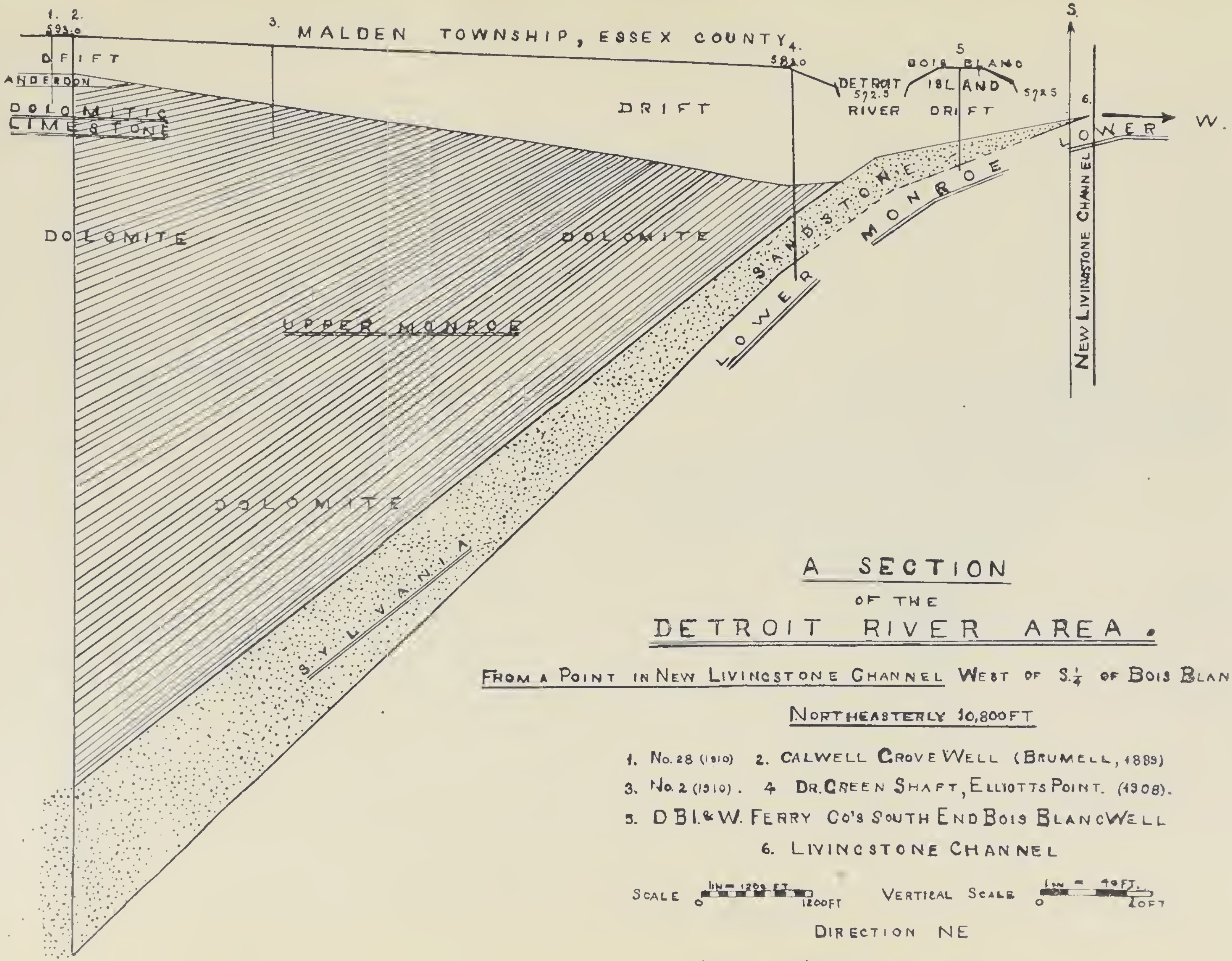
The deduction from this accumulated evidence is clamant of statement. It is this: If the dolomites above the Sylvania are Upper Monroe and the dolomites below the Sylvania are Lower Monroe—as is the common acceptation, then it follows that the rock underlying the Sylvania in the new Livingstone Channel in Detroit river is of Lower Monroe age.

Of this rock there is about 105 ft. of strata exposed in the "dry cut," which is 5,700 ft. in length, past Stony Island. The distance between the south end of the dry cut and the point at which a scraping of Sylvania sand was removed from the surface of the dolomite west of the south quarter of Bois Blanc Island, is about 8,500 ft. On the evidence of dredgemen, contractors, inspectors and government engineers the dolomites over this distance are not the same strata as were handled within the dry cut. So of the dolomites drilled and dredged between the north end of the dry cut and a point north of Ballards Reef, more than 9,000 ft. distant, where the strata fall away to a depth beyond the

[7]The Dr. Green Shaft.

[8]Geol. Survey of Canada, Part Q., Vol. V, 1889-90-91.

[9]As in Dr. Ami's report of Pelee Island well, "The Comber well," 1896, with 222 ft. of "limestone" over supposed Oriskany 40 ft., and dolomites, etc. As hitherto noted, there is an 84 ft. depth of sandstone below 228 ft. of, "limestone" at the east end of the farm next south of the Elliotts Point location. And about nine miles to the northeast of Elliotts Point there has been found to be 90 ft. of gray limestone (drillings), 260 ft. of brown dolomites and 30 ft. of Sylvania.



A SECTION
OF THE
DETROIT RIVER AREA.

FROM A POINT IN NEW LIVINGSTONE CHANNEL WEST OF $S.\frac{1}{4}$ OF BOIS BLANC ISLAND

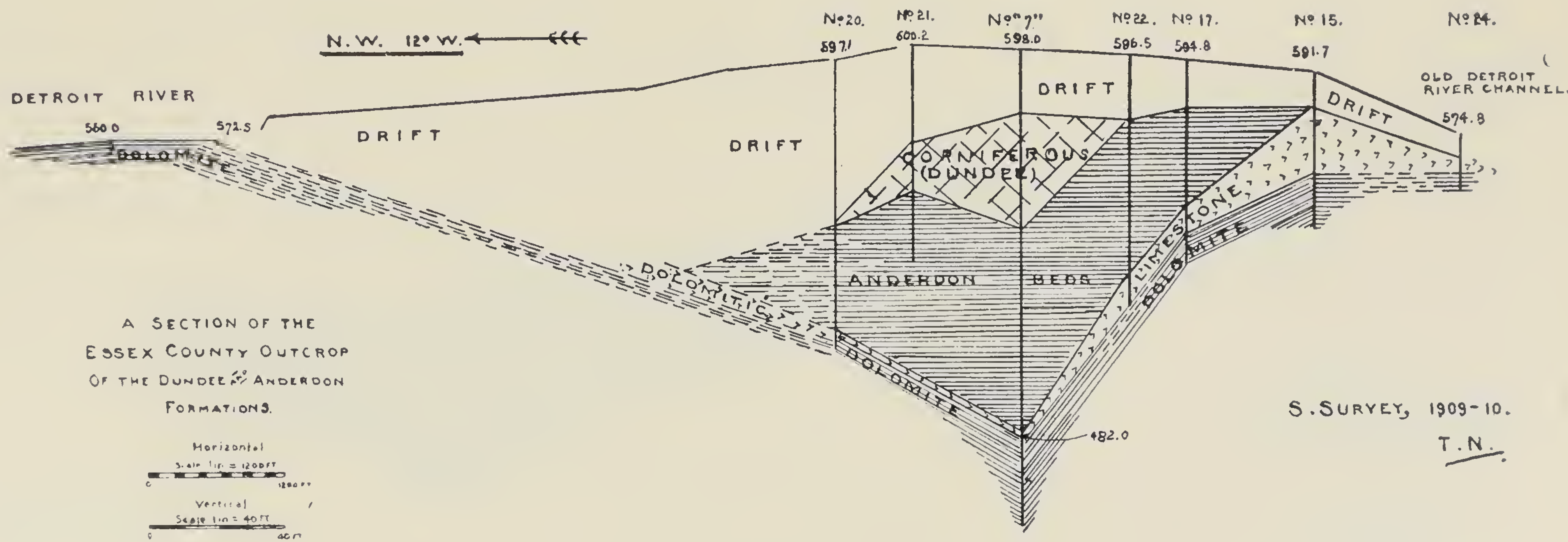
NORTHEASTERLY 10,800 FT

1. No. 28 (1910) 2. CALWELL GROVE WELL (BRUMELL, 1889)
3. No. 2 (1910). 4 DR. GREEN SHAFT, ELLIOTTS POINT. (1908).
5. D BI. & W. FERRY CO'S SOUTH END BOIS BLANC WELL
6. LIVINGSTONE CHANNEL

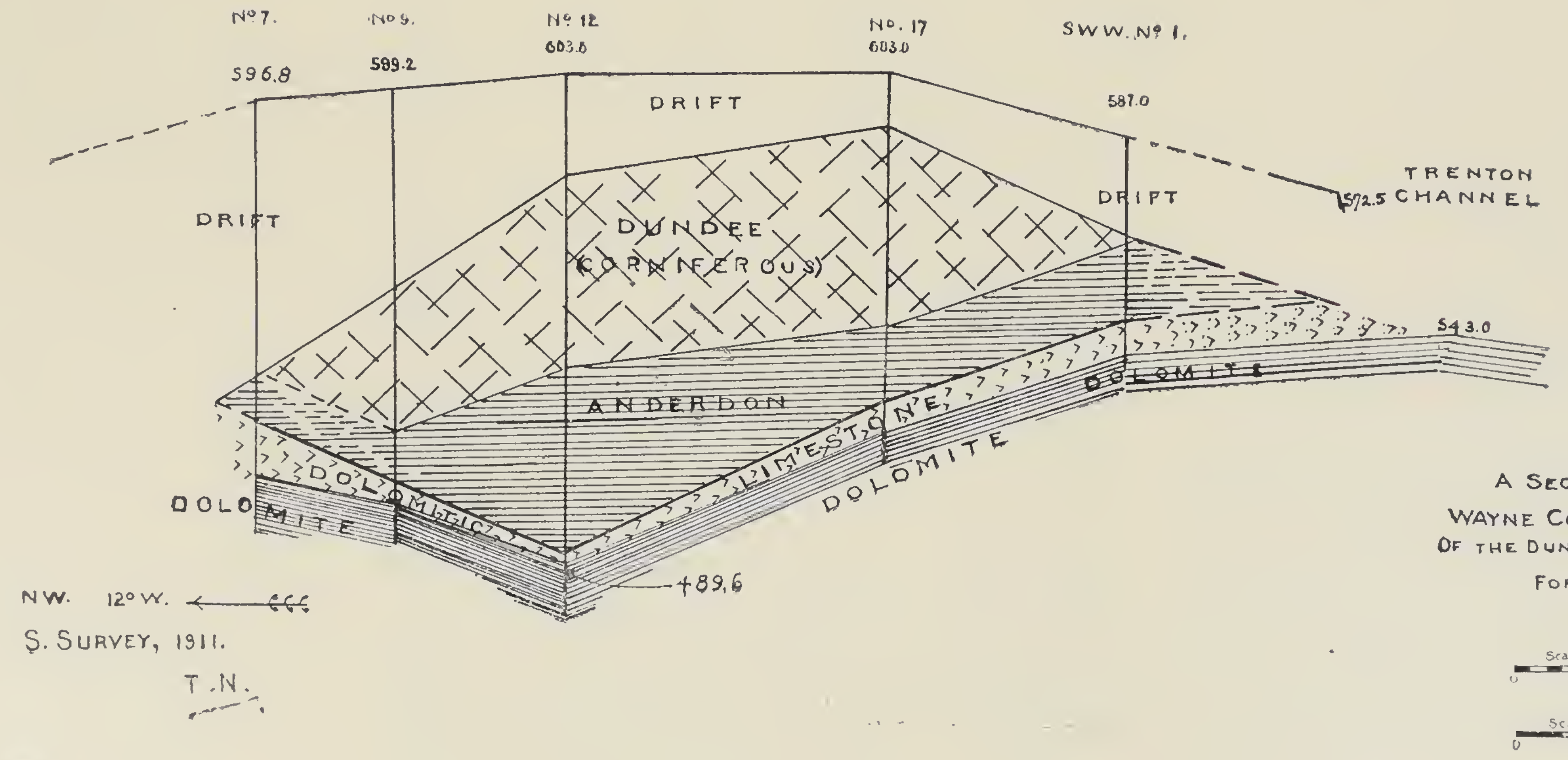
SCALE 1 IN = 1200 FT 0 1200 FT VERTICAL SCALE 1 IN = 40 FT. 0 40 FT

DIRECTION NE

THOMAS NATTRESS, AMHERSTBURG, ONTARIO



A SECTION OF THE ESSEX COUNTY OUTCROP OF THE DUNDEE AND ANDERDON FORMATIONS.



A SECTION OF THE WAYNE COUNTY OUTCROP OF THE DUNDEE AND ANDERDON FORMATIONS.

requirements of channel deepening. These also, on the same evidence and according to my own observation, are different strata from any south of them within the compass of our investigation.

Now, since the characteristic folding at the surface of the Silurian took place at the close of the Silurian age, and not during its continuance, it follows that the depth of strata laid down would be approximately proportionate to the distance in the direction from which newer strata were added on. Our distance from south to north is: 8,500 ft. + 5,700 ft. + 9,000 ft. = 23,200 ft. In the 5,700 ft. reach, as stated, about 105 ft. in depth of strata was exhibited in the dry cut. That gives approximately[10] 425 ft. of strata to be accounted for, all dolomite, and no trace of either Anderdon limestone beds or further trace of Sylvania sand within that depth and distance. The Corniferous strata and associated Anderdon limestone beds must, therefore, cross the Detroit river between the upper end of Grosse Isle and a point about abreast of the Salt Shaft at Delray, where the Corniferous (Dundee) is a surface extension.

Commenting upon the Devonian aspect of the Anderdon and Salt Shaft faunas, one gentleman of recognized position and ability has remarked, "With me, the most serious part of the proposition is that the fossiliferous horizon in the bed of the Detroit river carries a fauna also remarkably Devonian in its affinities." Whiteaves was of the same opinion at the time of his naming the *Panenka Canadensis*. Hence the confusion that has arisen.

Collections have been made from the fossil contents of these river-bed strata by the State Geological Department at Lansing, by the Dominion Survey at Ottawa, by Yale University, and by the University of Toronto, in addition to private collections. Consequently there is no lack of data for comparison. Stratigraphy and palaeontology seem to be in conflict. But, should the river-bed horizon, in relation to the Sylvania and to the Anderdon, still be held to be in dispute there is but one thing to do, and that is to take out a core at Stony Island in Detroit river and let it become the standard of reference for this area.

THOMAS NATTRESS.

Amherstburg, Ontario, February 19, 1912.

[10] To this approximation of 425 ft. must be added the 248 ft., or thereabout, of dolomitic limestone and dolomites between the bottom of the Anderdon and the top of the Sylvania in the Colwell Grove well to get the total depth of dolomite exposed in the Detroit River bed and in its immediate neighborhood on the Essex County side. That total thus obtained is 673 feet.

NOTES ON THE GEOLOGY OF THE GALLINA, NEW MEXICO, QUADRANGLE.

BY E. C. CASE.

During the summer of 1911 the author had an opportunity to examine, somewhat hastily, the geology of the region around the Mesa Prieta in the Gallina quadrangle. The points which it is desired to bring out in these brief notes is the close relation which exists between the structure of the region and the drainage of the country. The central portion of the quadrangle is occupied by the great Mesa Prieta, a block composed largely of Triassic and lower "red beds," capped by Jurassic and Cretaceous. The aridity of the area resulting in the sharp erosion features of such a climatic region brings into sharp relief the structural features.

The Mesa Prieta is separated from the Mesa de los Viejos on the northeast by a sharp fault occupied by the valley of the Chama river. On the southwest side of the mesa a second sharp fault separates it from the San Pedro mountains, this line is occupied by the intermittent streams called Poleo and Capulin Creeks. A glance at the topographic sheet shows that these two valleys are almost parallel in a northwest southeast direction. The structure of the San Pedro Mountains is totally different from that of the Mesa Prieta but the Mesa de los Viejos is nearly the same. The north side of the Mesa Prieta was not examined but a consideration of the map shows a series of small stream courses running into the Chama from the southwest and in many cases the mouths of these streams are almost exactly opposite the mouths of streams which enter the Chama from the northeast, running off of the surface of the Mesa de los Viejos. It was evident from a survey of this mesa made by a powerful glass from the surface of the Piedra Lumbre that these small valleys were on lines of breakage in the large mesa. The canon of the Arroyo Secco and that of El Cobre Canon, not shown on the map, but paralleling the Arroyo Secco on the east, are larger valleys along fault lines.

In the same line as the valleys just mentioned is a series of valleys in and on the borders of the Mesa Prieta to the east and southwest. The valley of the Puerco river runs in a nearly northeast southwest direction and a second great fault forming the cliff of the Mesa Prieta on the south east side runs in the same direction and is apparently a direct continuation of the line occupied by the Arroyo Secco. Between the Mesa Prieta and the Capulin Mesa, a western portion of the same block, there is a sharp valley occupied by an intermittent tributary of Capulin creek. Between the Capulin Mesa and the Cerro Blanco is another sharp break parallel to the other lines mentioned. The valley of the Gallina river does not occupy a fault line but is guided by the upturned edges of the Mesozoic strata which here dip sharply to the west or northwest and within a short distance are overlain by the horizontal strata of the Puerco and Wasatch Tertiary beds.

Between the valley of the Puerco river and the base of the Mesa Prieta is a flat area inclined downward toward the northeast. At the junction of the Puerco river and Poleo creek the surface of this area, here called the Mesa Poleo, has an elevation of approximately 7,500 feet; further down the course of the Puerco there is another block with an elevation of between 7,000 and 7,300 feet and beyond this to the Chama the surface is about 6,500 feet. These three areas are separated by sharp faults which are occupied by intermittent streams. It will be noticed that the valleys of these streams are very closely parallel to the valleys of the Chama river and Poleo and Capuli creeks.

The dip of the strata of the Mesa Prieta and the Mesa Poleo are slightly to the northeast; on the south side of Poleo Creek the strata dip very sharply to the southwest, on the southeast side of the Puerco river the strata are nearly horizontal.

The notes on this quadrangle are here recorded for the use of those who wish to study the orientation of the drainage lines in a region where the structures is very evident.

CORRELATION OF LAKE AGASSIZ WITH GLACIAL LAKES IN GREAT LAKES BASINS.

BY FRANK LEVERETT.

Abstract.

The moraines which correlate with the Port Huron morainic system seem to embrace a system that sweeps around the head of Lake Superior, from which it appears that no glacial lake could have formed in the western end of the Superior basin until after the time of Lake Whittlesey. Lake Duluth probably correlates with Lake Wayne, the successor of Lake Whittlesey, each lake being dependent upon a large recession from the Port Huron morainic system. The correlative of the Port Huron morainic system in the region covered by ice from the Keewatin field seems to be found in the "gray drift" border in Minnesota, for glacial drainage from the border of the gray drift in the St. Louis basin was controlled to a marked degree by the ice lobe in the Superior basin at the time of the development of the morainic system at the head of the lake, which as stated above, is likely to be the correlative of the Port Huron system. A great recession of this western field on this interpretation would be necessary before Lake Agassiz could come into existence. The beginning of Lake Agassiz may, therefore, have been as late as the lowering of the waters of the Superior basin to the level of Lake Algonquin. Some support for this interpretation is found in the deformation of shore lines. Studies in the basins of the Great Lakes have shown that but little deformation had occurred down to the time of Lake Algonquin. But during the life of Lake Algonquin great deformation occurred. The same is true of beaches of Lake Agassiz, there having been a great amount of deformation during its life, and a splitting of every beach when traced northward. The correlation of moraines and the evidence from deformation seems, therefore, to be in harmony in making Lake Agassiz a correlative of Lake Algonquin rather than of any earlier lake stage.

THE ORIGIN OF CONTINENTAL FORMS II.

A year ago, before this section, I presented certain geological evidence in support of four distinct yet closely related propositions, an outgrowth of the theory of continental origin first advanced by the Reverend Osmund Fisher.* These propositions were as follows:

1. The present geographical plan is the result, primarily, of the separation of mass from the earth.
2. This separation marked the close of the Mesozoic division of geological time as determined by the sedimentary series of southern France.
3. The separation was caused by extraterrestrial gravitation.
4. The event was sudden.

While now venturing once more to draw attention to these propositions I desire fully to recognize their debatability and to make it clear at the outset that they in no way form the basis of the discussion now attempted. They serve, indirectly, to introduce a problem in connection with relative levels of land and sea.

At the close of that paper I mentioned ten objections, of various degrees of importance, which militate against these propositions, of which the most serious one apparently, first raised by Barrell,† is that the present oceanic waters, distributed over the surface of the earth before the separation, would average in depth about 10,400 feet which is contrary to the claims of Pickering‡ who discussed the theory in 1907, and also to my claims as set forth in the four propositions.

The natural presumption is that the oceans have maintained a fairly constant volume through long stretches of geologic time, *presumption* meaning, of course, not *certainty* by any means, but merely that degree of probability which requires the strongest of evidence to overcome it. The evidence is very strong, perhaps strong enough even for that, but whatever the final decision, there may still be some advantage in the viewing of old facts from a new standpoint, and the present paper is an attempt at an impartial analysis of as much of the evidence as has so far been obtained bearing upon this question of oceanic volume.

Barrell's objection, if valid, could be urged with special force against my claim that the geography of the Pacific hemisphere indicates that all the lands gravitated toward the present site of Australia, actually sliding, from various directions, into a huge depression in the side of the earth. Had the ocean volume not long after this been the same as it is now, Australia and the neighboring islands would presumably have been all submerged, but such a submergence is not indicated by either their geology or their biota.

The present oceans, covering approximately three-fourths of the earth's area, average in depth, according to Humboldt and others, between two

*Fisher, Rev. Osmund, "On the Physical Cause of the Ocean Basins" "Nature," Jan. 12, 1882, pp. 243-244.

†Barrell, Joseph, Review of W. H. Pickering's "Place of Origin of the Moon" etc., Journ. of Geol. Vol. XV, 1907, pp. 503-507.

‡Pickering, William H., "The Place of Origin of the Moon,—The Volcanic Problem." Jour. of Geol. Vol. XV, 1907, pp. 23-38.

and a half and three miles. If we could restore to the earth and distribute over its surface, the crustal materials similar to those of our continents, which are claimed to have been taken away, the oceanic water would lie about two miles deep, on the average, the world over.

Our ocean basins, so-called, which are in reality the major portion of the globular area, being the direct result of the removal from the earth of some of its surface materials, how can we suppose that any such basins existed prior to that separation even upon the large unknown area which is claimed to have been denuded of its crust?

One of the results of the systematic investigation of continental structure has been to teach that while in Mesozoic time large areas that are now land were covered by water containing marine forms of life, these Mesozoic marine waters were not of such profound depth nor great expanse as would be necessary to account for any considerable portion of the oceans as they stand today. The Mesozoic record tells of very considerable areas of land interspersed with epicontinental seas of shallow or moderate and often of fluctuating depth. Certainly the facts give no hint of a world-wide ocean two miles deep.

And if, in devotion to the theory, one attempts to dispose of the present excess of oceanic water by postulating great and deep depressions upon the unknown denuded portion of the earth's area, he is confronted with an important and growing body of evidence in support of the belief that the earth's crustal materials are in a state of approximate isostatic equilibrium with respect to the underlying matter. There are also certain biological objections which he encounters but their mention must be reserved for another place.

The first two propositions taken together, then, stand confronted with the present volume of oceanic water. If the volume was the same in Mesozoic time that it is now there must presumably be something wrong with the data or the chain of reasoning by which the propositions have been reached. But was it the same? *Geology is silent.*

Regarding the combined ocean beds as a container of water we have to contemplate the possibility of changes taking place in the capacity and in the form of the vessel as well as in the volume of the contents. Questions of level separate themselves from questions of amount.

Up to the time of Sir Charles Lyell it was commonly thought that the general level of the ocean had fluctuated, but he was able to sway geological opinion and to establish the dictum that throughout the geological changes it has been the land which rose and fell, to be in turn, more free from or more submerged in the waters of the sea. The masterly way in which he connected observed present processes and observed past effects need not be praised today; but is that all? Did Lyell establish constancy of ocean volume? No. Nor has any one else. Nor yet, in any considerable degree, has *inconstancy* been proved. The question has not been widely discussed* and is an attractive one for further investigation.

Under the epeirogenic theory of the glacial period as built up by Dana, LeConte, Jamieson, Wright, Upham, Spencer and others, three altitudes are recognized for continental lands in Pleistocene time. They are:

*Mainly by Suess, Gregory, Geikie, Belt and Tylor.

1. *Elevation* to the extent of several thousand feet above the present level, corresponding to the Glacial Epoch.

2. *Depression* to several hundred feet below the present level, corresponding to the Champlain Epoch.

3. *Reelevation* to the present level, corresponding to the Terrace Epoch and later time.

Upham* voiced the prevailing sentiment when he attributed status 1 to secular contraction with intermittent yielding of a partially rigid crust; status 2 to breakdown of the arch from weight of ice and status 3 to relief of load from the melting.

According to Dana,† the "upward, downward and again upward movements of the crust in the Quaternary age, corresponding to the Glacial, Champlain and Recent periods, affected the higher latitudes of the northern hemisphere on all its sides," and (he continues) "it is probable that these movements of the northern hemisphere were attended by parallel movements in the southern."

It does not seem to have occurred to him to wonder how such vast vertical movements could be simultaneous over such large portions of the area of the globe. The movements which he believed went on at the same time in the southern hemisphere are spoken of as "parallel," not compensatory. Supposedly, for one part of the crust to rise, since it must do so by virtue of gravitation, some other part must sink. It would seem that any terrestrial distortion must take this course, even if of tidal origin.

Now it so happens, in spite of this seeming oversight, that Professor Dana's opinion is susceptible to very remarkable substantiation, so that it becomes increasingly probable that the movements referred to had in reality a world-wide distribution and were truly "parallel" and simultaneous and not compensatory, only they do not seem to have been movements of just the sort that he contemplated. The evidence upon these points, bearing upon the relation of the hydrosphere to the lithosphere, is simple and direct and is of two kinds; we have (A) the purely geological data, including for convenience the bathymetrical also, and we have (B) a mass of data in connection with the geographical distribution of plants and animals in this and other geological times. It may not be improper to anticipate at this point sufficiently to remark that the geological evidence indicates a former greater emergence of many lands above the sea than obtains at the present time and that the biological evidence forms a secondary line supporting the first.

*Upham, Warren, "Probable Causes of Glaciation," Appendix A, Wright's "The Ice Age in North America," 1889.
Upham, "Epeirogenic Movements Associated with Glaciation." Am. Jour. Sci., Ser. 3, vol. xlvi, 1893, pp. 114-121.
Upham, "Causes and Conditions of Glaciation."
Am. Geologist, vol. xiv, July 1894, pp. 12-19.
Upham, "Evidence of Epeirogenic Movements Causing and Terminating the Ice Age." Bull. Geol. Soc. Am., vol. 10, 1899, pp. 5-10.
†Dana, James D., "Manual of Geology," 1876, p. 746.

(A) GEOLOGICAL EVIDENCE OF FORMER ELEVATION.

We will take first the geological (and bathymetrical) division, listing the lines of evidence of former elevation of lands relative to sea level as follows:

1. Glaciation.
2. In addition to the above, Fjords excavated by ice far below the present sea level.
3. The presence of submerged valleys of river erosion upon the continental borders.
4. Other geological evidence, the nature of particular formations, etc.

GLACIATION.

To whatever degree the epeirogenic theory of glaciation is accepted, glaciation itself becomes admissible as evidence of former greater altitude above the sea. To that extent it is offered as bearing upon the present discussion. Figure 1, in addition to the conventional areas of North America and Europe includes also certain others, of small extent, for instance the Alps, where there are signs of a former greater extent of glaciers which are now comparatively small; similarly the Lebanon, Himalaya, Atlas and Andes mountains,* New Zealand and southeastern Australia.

In the highlands of Nicaragua, Belt† found transported boulders and other signs of glaciation (with the exception of grooved rocks) as characteristic, as he remarked, as any in Scotland.

Whatever one may think of Professor Agassiz'‡ opinion that South America was formerly glaciated right up to the equator, he did find large transported blocks in the mountains not very far from the Amazon and he seems safe in the inference that these mountains at least were formerly considerably glaciated. His observations were substantiated by his fellow-traveler Hartt§ who also found morainic deposits in the southeastern part of Brazil near the coast.

These small scattered occurrences of glaciation where there is now none or where the glaciers if present are much smaller than they were once, are offered in evidence conditional upon the acceptance not only of their verity but, together with the larger areas, upon the acceptance of the theory that glaciation was brought about principally by the differential elevation of the land to the local line of perpetual snow. Different estimates of the amount of elevation which would be required to reglaciate North America to the former extent vary from 3,000 to 8,000 and even 10,000 feet.

FJORDS.

Figure 2 illustrates the principal regions where fjords have been excavated by glacial ice to considerable depths below the present level of the adjacent seas. All the arctic lands of America, the coast from Puget Sound to the Alaskan Peninsula, Greenland, Scandinavia and doubtless Spitzbergen also, are included in this category. Also, possibly

*See Darwin, Charles, "Origin of Species," 1859, Levant Ed. pp. 366-371.
†Belt, Thomas, "The Naturalist in Nicaragua," London, 1874.
‡Agassiz, Louis, and Mrs., "A Journey in Brazil," (Thayer Expedition 1865) 1886.
§Hartt, Ch. Fred, "Geology and Physical Geography of Brazil," S 1870.

the region of the Great Lakes of North America, for their bottoms are considerably lower in places, than the present level of the sea, and whether formed by glacial ice, or, as according to Spencer's excellent work,* by the subaerial baseleveling of great river systems, these must be taken as evidence of former higher altitude of the region relative to the level of the sea.

Darwin, Agassiz and Dana speak for the Pacific coast of Patagonia, and Dana likewise for New Zealand and Tasmania.

In one of the fjords of eastern Greenland a sounding of 3,000 feet failed to find the bottom.†

SUBMERGED VALLEYS OF RIVER EROSION ON CONTINENTAL MARGINS.

Closely related to the channels cut by moving ice are those cut by moving water. It is now well known that not only do the continental plateaux extend out under the sea to the depth of 100 fathoms, but these submerged borders are in places deeply channelled as if by river valleys and gorges. The great preponderance of geological opinion is that they could have been formed in no other way than by rivers.‡ Suess,§ dissenting from this prevailing opinion, mentions that there is a similar gorge or valley in Lake Constance, where the Rhine flows through, but to this we may easily object on the grounds that no good reason appears why it may not be properly explained by ponding of the waters after the old gorge was cut by the river. He seems to approve also the opinion of a French writer to the effect that the submerged depression which is found at the mouth of the Rhine cannot be attributed to river erosion because it is asserted that, were that the case, sedimentation would ere this have obliterated it.

When Buchanan‖ found such a submerged gorge something like 80 miles long at the mouth of the Congo, he interpreted it as the result of building up of the sides by deposition instead of erosion by the river when the now submerged continental border was above the sea. Suess also approves this but it fails wholly to take account of similar and related phenomena which are scattered widely over the world. With these exceptions, geological opinion seems to be unanimous that the drowned gorges and valleys on the submerged continental margins are explainable only on the basis of former elevation above the level of the sea.

Figure 3 shows the distribution of certain well-authenticated instances of this "river drowning" and the amount of vertical movement which they are held to indicate.

On the Pacific coast of the United States the original work was by

*Spencer, J. W., "Origin of the Basins of the Great Lakes of America," Quart. Jour. Geol. Soc. London vol. 46, 1890.

†Upham, Warren, "Submarine Valleys on Continental Slopes," Proc. Am. Ass. Adv. Sci., vol. 41, 1892, pp. 171-173.

‡See Upham, Warren, loc. cit. and also "Fjords and Submerged Valleys of Europe." Am. Geol. vol. xxii, 1898, pp. 101-108.

§Suess, Eduard, "The Face of the Earth." Eng. Trans. vol. ii, Chap. xiv "The Oceans."

‖Buchanan, J. Y., "On the Land Slopes Separating Continents and Ocean Basins, especially those on the West Coast of Africa." Scottish Geol. Mag., vol. iii, May 1887, pp. 217-238.

Davidson,* and the discussion by LeConte,† Lawson,§ Fairbanks,‡ Upham¶ and others.

Davidson found 20 or more submerged valleys along the coast of California and Lower California, of which the most classical example is the one heading up in the Bay of Monterey. Several small streams empty into this bay but there are no large rivers; Fairbanks however shows how this may not always have been the case. Davidson's plate ix shows a beautifully marked valley which he has sounded out to about 20 miles from shore. About 10 miles out it received a tributary from the northeast. Capt. Tanner of the U. S. S. "Albatross" is cited as having sounded 868 fathoms (5,208 feet) in the main channel 16½ miles off shore. Davidson's soundings cease sooner than we might wish, for the edges of this valley, as of several of the others, are still running out to sea when his figures stop. The 868 fathom depth is a good five miles inside the valley as shown on plate ix and we have nothing to indicate the real outer limit.

Considering all the features along this coast and northward to Alaska, Upham thinks that there must have been an elevation during the Glacial Epoch amounting to 3,000 to 5,000 feet. LeConte's estimate is somewhat less, 2,000 to 3,000 but even the largest of these figures appear to be well on the side of caution for with 5,208 feet only 16.5 miles out in the submerged Monterey valley and the contours running out in typical form upwards of five miles more it is evident that if this valley was formed by river erosion the old base-level is now more than 5,208 feet submerged.

It may be remarked parenthetically in this connection that there are excellent reasons for suspecting that the whole Gulf of California may be a drowned valley down which formerly coursed the lower reaches of the Colorado River.

LeConte, Fairbanks and Upham agree in making the elevation contemporaneous with glaciation, and the depression which followed is made an equivalent of the Champlain Epoch in the East. This matter of the time is of great importance. We shall see as we proceed how many of the signs of former elevation followed by subsidence seem to fall into this same correlation.

The mouth of the St. Lawrence has a well marked submarine gorge which lies drowned to the depth of 3,666 feet.** Spencer places the glacial elevation of North America at "3,000 feet or more," but there are reasons for believing that the observed depth at the mouth of the St. Lawrence gorge (3,666 ft.) may fail to express the whole of the elevation, especially elsewhere on the continent, at the time that the gorge was in process of formation.

At the mouth of the Hudson, Lindenkohl†† sounded out a typical gorge.

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*Davidson, George, "The Submerged Valleys of the Coast of California U. S. A., and of Lower California, Mexico." Proc. California Acad. Sci., Ser. 3, Geology, Vol. 1, No. 2. 1897, pp. 73-103 and plates IV-XII.

†LeConte, Joseph, "The Mutual Relations of Land-elevation and Ice-accumulation during the Quaternary Period." Bull. Geol. Soc. Am., vol. 2, 1891, pp. 323-330.

§Lawson, A. C., Bull. Dep't. Geol. Univ. California, vol. 1, pp. 57-58, 157-159.

‡Fairbanks, Harold W., "Oscillations of the Coast of California During the Pliocene and Pleistocene." Am. Geol. vol. xx, 1897, pp. 213-245.

¶Upham, Warren, 1892, loc. cit.

**Spencer, J. W., "The High Continental Elevation Preceding the Pleistocene." Bull. Geol. Soc. Am., vol. 1, 1890, pp. 65-70.

††Lindenkohl, A., "Geology of the Sea-bottom in the approaches to New York Bay." Report of the Sup't. U. S. Coast and Geodetic Survey. 1884, Appendix No. 13, pp. 435-438, with plate.

except for a bar which has formed across the mouth of it, and the observed depth is 2,844 feet.

Passing south along the coast the mouth of the Susquehanna river is a similar instance and Spencer* has shown the details of numerous cases of the same sort, so that from the Susquehanna southward, around the shores of the Gulf of Mexico and on to the Orinoco there are as many as 25 or 30 all having the same general characteristics and all being apparently favorable to a reference to pleistocene time.

Spencer's results in this region have quite generally been regarded as excessive. From a faunistic standpoint it is hard to credit the very great extent of land which the deeper drownings would perhaps indicate, running as they do down to depths of 12,000, 14,000, and 17,000 feet. In the Bartlett Deep south of Cuba a channel coming in from the east goes down even to 18,000 feet. It would seem reasonable to suppose that more than one cause may have operated to give these depths. Bartlett Deep stands in the relation of a foredeep for the Cuban mountains and throughout the Antillean region crustal conditions seem to have been anything but stable. The fact of the numerous drowned channels seems well enough established but we may hesitate to use the larger values in making up any average with similar instances elsewhere.

On the west coast of the British Isles Hull† found a similar channel which is now submerged 7,800 feet and in the Bay of Biscay one of no less than 9,000 feet, which is getting well up toward two miles.

On the west coast of Africa, just north of the equator and near the meridian of Greenwich, Buchanan found one which he called the "Bottomless Pitt" which sounded 2,700 feet; but the greatest of them all in clearness, length and general conformation is the one which he figures for the mouth of the Congo. It is 6,000 feet deep. It extends out to the edge of the continental shelf, a distance of about 80 miles, it is cut in that shelf, and its drowning, like that of all the others of its class, is inseparable from the drowning of the continental border in which it is situated. Further on, when we see how the submerged border is fairly a unit feature all over the world, we shall see how these drowned rivers and with them the lands themselves even though scattered, are susceptible of correlation in their drowning, making their elevation high above sea level during the Glacial Epoch (possibly before) terminate with the Champlain depression in eastern North America.

Since all of the information relative to these submerged river valleys and the mouths of fjords is derived from soundings in the ocean near the land it is obvious that most of the observed depths must be minima. How much deeper they would be in the absence of sedimentation which must have occurred we can only guess, but we find some hint in the fact that western Britian gives an instance of 7,800 feet, the Bay of Biscay 9,000 and the mouth of the Congo 6,000.

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*Spencer, J. W., "The Reconstruction of the Antillean Continent," Bull. Geol. Soc. Am., Vol. 6, 1895, pp. 103-140. With plate.

This author speaks of these river channels as "fjords" but it seems best to include them here with the other instances of river-as distinguished from ice-erosion.

†Hull, Edward, "The Submerged River-valleys and Escarpments off the British Coast." "Nature," vol. lvii, 1898, p. 184.

Hull, "Sub-Oceanic Terraces and River Valleys of the Bay of Biscay." "Nature," vol. lvii, 1898, p. 582.

Hull, "Sub-Oceanic Terraces and River Channels off the coast of Spain and Portugal," "Nature," vol. lviii, 1898, p. 51.

There are two or three factors to be taken into consideration in this connection. In the neighborhood of severe glaciation the borders of the North Atlantic must have received heavy blankets of sediment and elsewhere as well, where these drowned river mouths are found, they are in precisely the best situations for heavy sedimentation. An exception may be noted in the southeast part of the Bay of Biscay, where there is now no very large river to carry down silt, and it may be of some significance that here we find a 9,000 foot depth. There is also, however, the possibility that some of this 9,000 feet represents isostatic depression by the Pyrenees mountains close by.

The sediment of the Congo appears, according to Buchanan, to be carried northward and deposited along the bank rather than out over the old channel.

Again, the figures for North America, aside from the Antillean region run lower than those for Europe and Africa and it may be that the heavy load of ice which the northern part carried caused it to stand at a lower level than the lands which were glaciated lightly or not at all, so that the rivers sooner reached their baselevels of erosion. By the same influence the relief when the ice melted would permit more of that elevation which corresponds to the Terrace epoch and bring the drowned vales still nearer the surface of the sea. But regardless of these finer and more debatable points, the submergence which marked the close of the Glacial epoch runs into figures which, on the average, may be not unfairly expressed as a mile or more. (The matter of correlation will receive attention as we proceed.)

OTHER GEOLOGICAL EVIDENCE.

Sedimentary deposits washed down by the Mississippi to the Gulf region, the so-called "modified" or stratified drift, prompted Hilgard* to assign to the upper part of the Mississippi valley a former elevation above sea level of 4,000 to 5,000 feet.

He also inferred, from the character of the later Tertiary deposits in the gulf region that prior to the Glacial or Drift epoch the Gulf of Mexico was nearly or quite isolated from the Atlantic ocean, probably by elevation of the northern borders of the Caribbean sea, so that it was freshened by the inflow from the land. This inference receives strong corroboration from another quarter, as we shall have occasion to remark in connection with the distribution of land and freshwater shells and crustacea.

Falconer† reviewing the various phases of this antillean elevation, dates the high emergence of the islands from about the beginning of the Tertiary and thinks it terminated in sinking during the Pleistocene period.

Passing southward to Brazil, Hartt‡ contemplates the distribution of the so-called "drift" between Porto Novo and Porto das Caixas and at Bahia and considers that when it was deposited the land stood at a higher level than now. The time of this "drift" deposit was placed by

*Hilgard, Eugene W., "The Age and Origin of the Lafayette Formation." Am. Jour. Sci., Ser. 3, vol. xliii, 1892, pp. 389-402.

†Falconer, J. D., "The Evolution of the Antilles." Scottish Geographic Magazine, vol. xviii, 1902, pp. 369-376.

‡Hartt, Ch. Fred, "Geology and Physical Geography of Brazil." 1870.

Hartt and Agassiz at the Glacial epoch in the northern hemisphere. Hartt says (p. 572) "it would seem that the great movements just antecedent and posterior to the drift period in South America have corresponded with those of North America during the same period."

Figure 4 illustrates the three regions of elevation, followed by subsidence presumably Champlain in time, which have just been mentioned. It might include also Fairbanks' conclusion that the rivers of the California coast form a separate line of evidence strongly corroborating the testimony of the submerged river channels in that region. It is true that Falconer seems to make the Antillean subsidence slightly earlier, but since it too is related, like all the rest of these features, to the submarine continental border it would seem that it must ultimately be referred to the same time.

We have now run briefly over four distinct groups of facts derived directly from geological observation by various observers who speak independently and collectively of elevation followed by subsidence of various lands relative to the level of the sea. The figures, as far as we have any, are in thousands of feet, averaging roughly a mile or more. The timing, as far as we have it, is in close agreement over wide ranges of latitude and longitude. But suppose we question that last point. Are we not familiar with slow elevation or depression of various coasts? The sea is said to be losing today along some of the coasts of South America and Scandinavia and gaining on Iceland and Greenland.

It has not yet been definitely proved that the glaciation which involved the southern lands was simultaneous with that of the North. Dr. Croll and even Darwin thought that the facts would be as well explained by alternate glaciations of the northern and southern hemispheres. Of course the opinions of Hartt and Agassiz may constitute more than an offset for this but it should be borne in mind nevertheless.

The elevation of North America and northwestern Europe have, I believe without dispute, been made coeval and conterminate with the glaciation of those regions and with each other. Further on we shall see that the concensus of opinion is strongly toward the conclusion that Dana arrived at and that was expressed by Hartt and Agassiz that these movements, even though widely distributed, are all essentially related and essentially simultaneous.

Let us turn now for a moment from the contemplation of the rocks, the glaciers and the rivers to compare with what we have found the distribution of those plants and animals whose evolution and spread, whose very existence is inseparably linked with these geological and geographical features. If we are conscious of any feeling of distrust, distributional data seeming less capable of carrying us safely through critical investigations, it may in part be dispelled by recalling how completely in its progress inorganic geology has been intertwined with palæontology and how thoroughly the living world has been investigated by an army of careful students. I venture to think that, with care, distributional data may be made to yield results hardly less valuable than those of a purely geological nature.

(B) BIOLOGICAL EVIDENCE OF FORMER ELEVATION.

The second division of the evidence which, as we shall see, accords with the first in indicating a former higher altitude above the sea of

various regions now low or wholly drowned, rests upon the fact that in these several regions land animals and plants and freshwater animals are found so distributed that only former connections hospitable to them can account for their observed occurrence. In some cases the land connections are drowned in the sea. In others, as the freshwater forms, the saltness of the water is the feature that renders intercommunication impossible, in still others the connecting lands have become inhospitable not through drowning but by change of climate which is best interpreted in terms of altitude. The time of the various connections and of their disappearance have been inferred from the palæontological succession and from the amount of differentiation by which groups now separated appear to have diverged since the disappearance of the "bridges" over which they were once continuous. For many of the extinct bridges this discussion has no place because they belong to Mesozoic time. Such, for instance, are those between the now widely separated land masses of the southern hemisphere. Still others, notably the supposed Tertiary connection between Europe and America via. Greenland, are omitted because they are open to question for one reason or another and are to be dealt with in a later communication.

Even with an attempt at caution, some items of evidence have doubtless been included which will be challenged by many, but it is confidently hoped that after all crude errors shall have been eliminated there will still remain sufficient widely distributed evidence of Pleistocene elevation and postglacial depression to form an adequate basis for the critical analysis which is attempted.

BERING BRIDGE.

It was, I believe, Professor Huxley who first suggested a former land bridge between Alaska and Siberia to account for the distribution of plants and animals. This suggestion, welcomed by Dr. Wallace, has been accepted by practically everyone since, and while there are certain difficulties with it and it may possibly, later on, be found to have been a less important factor than is now thought, it is at the present one of the least debatable instances of a land connection, of late Tertiary and Pleistocene time, now submerged. While the amount of elevation required to obliterate the present Bering Strait is slight, there are not lacking indications that in Pleistocene time and earlier there was a highway far enough to the south to accommodate forms which would presumably find a cold climate a barrier not to be passed in competition with others better adapted. The Bering Bridge has therefore been widened by some to include the Aleutian Islands; by others they are still omitted.

SANTA BARBARA ISLANDS.

In connection with the submerged valleys of river erosion and the testimony of the present rivers of California, which LeConte, Fairbanks and Upham believe clearly establish the vertical movement of that region, we have the authentic record of the finding on the Santa Barbara Islands of the bones of extinct Quaternary mammalia, including the Mammoth, under circumstances that preclude the possibility of their occurrence being adventitious. This fact alone is held to establish the former connection of the islands with the mainland.

No evidence has been detected that the movements of the islands have been independent of those of the neighboring coast, on the contrary they appear to have shared those of the mainland throughout. The later of these movements have been fully correlated by high authority with the Glacial elevation and Champlain depression of the East.

NICARAGUA.

In Nicaragua, Belt* found evidence that the glaciers came down from the mountains to the present 2,000 foot level. He speaks of unstratified drift with transported boulders as large as fifteen feet across and eight miles from their parent rock. He is not sure that the glaciers did not come down even lower than the level named.

In the matter of the life of the region, he reasoned that it must have survived the cold spell without migrating any great distance, that there must have been fairly extensive lowlands near by in order for it to survive, that this period of cold was apparently identical with the period of a land connection between Yucatan and the Greater Antilles and from other data also he believed that during the Glacial period Nicaragua stood much higher relative to the sea than it does now. He attributed this to the ocean being lowered by the abstraction of water which was stored up in the form of glaciers elsewhere.

THE WEST INDIAN REGION.

Bland,† studying the land mollusca of the Antilles found the fauna of Cuba and the remainder of the east-and-west component, the Greater Antilles, to be derived from Mexico and Central America; that of the north-and-south component, the Lesser Antilles, to be derived from South America by the way of Trinidad.

Simpson‡ emphasizes the "rather intimate" relationship of the Greater Antilles with Central America and Mexico and the much more remote one with the Lesser Antilles.

Ortmann,§ mainly on the basis of the freshwater crustacea, believes in a pleistocene connection between the Greater Antilles and Central America which was destroyed in recent time. He holds similar views in regard to the connection of the Lesser Antilles, Trinidad and the South American mainland, citing Simpson as favoring the drift theory for the shells but, himself, believing that the decapods demand a land bridge.

Pilsbry‖ concurs on this connection, and in view of the weight of opinion in its favor it becomes interesting to learn what depths of water now separate these islands, since these depths may be regarded as approximately the measure of the vertical movement that has converted them from a fairly continuous ridge into the present chain of islands. We find on

*Belt, Thomas, "The Naturalist in Nicaragua." London, 1871.

†Bland, Thomas, "Notes relating to the Physical Geography and Geology of and the Distribution of Terrestrial Mollusca in certain of the West India Islands." Proc. Am. Philos. Soc., vol. xii, 1871, pp. 56-63.

‡Simpson, Charles Torrey, "Distribution of the Land and Freshwater Molluscs of the West Indian Region, and their Evidence with Regard to Past Changes of Land and Sea." Proc. U. S. Nat. Mus. vol. xvii, 1894, pp. 423-450.

§Ortmann, A. E., "The Geographical Distribution of Freshwater Decapods and its bearing upon Ancient Geography." Proc. Am. Phil. Soc., vol. xli, 1902, No. 171, pp. 267-400.

‖Pilsbry, H. A., "Non-Marine Mollusca of Patagonia." Reports, Princeton Univ. Expeditions to Patagonia, 1896-1899, vol. iii.

reference to the charts that the initial difficulty to be encountered by land animals starting to migrate north from the mainland or from Trinidad is a depth of 2,216 feet. Further north, about the middle of the chain, we have depths of 8,076 feet, 7,392 and 6,468, diminishing again still further north to 2,700 and 2,088. From 6,000 to 8,000 feet therefore is an inside estimate of the amount of vertical movement indicated.

Falconer's resumé of the subject has already been mentioned. It is worth emphasizing that the facts of animal distribution in these islands have led to exactly the same conclusion that was reached by Hilgard* in the study of the "Grand Gulf" formation along the shores of the Gulf of Mexico, namely, that up to the Glacial Epoch, (not necessarily ending at the beginning of that epoch) there was such an elevation of the northern and eastern borders of the Caribbean Sea that the waters of the Gulf were separated from those of the ocean and became brackish or even fresh from the preponderance of the inflow from the land. It seems as though this combination of indirect geological and direct biological inference ought to be very reliable, and it is interesting to notice that the figures involved, 6,000 to 8,000 feet, while higher than those obtained for heavily glaciated North America, correspond very well with others that we have for South America and Africa. The depths between the islands must be increased by whatever sedimentation has occurred, so that they by no means form a maximum limit of the drowning. The natural presumption is that these submerged places were well above sea level to begin with, and that now, submerged, the connecting ridges have been built up by sedimentation. Orogenic movements, however, must be borne in mind, especially in this region.

SOUTH AMERICA, AFRICA AND INDIA.

As bearing upon the climate and altitude of tropical South America, Africa and India in the Glacial Epoch, I will quote Darwin's† summary of a discussion of related facts.

"From the foregoing facts, namely the presence of temperate forms on the highlands across the whole of equatorial Africa and along the Peninsula of India to Ceylon and the Malay Archipelago, and in a less well-marked manner across the wide expanse of tropical South America, it appears almost certain that at some former period, no doubt during the most severe part of a Glacial period, the lowlands of these great continents were everywhere tenanted under the equator by a considerable number of temperate forms. At this period the equatorial climate at the level of the sea was probably about the same with that now experienced at the height of from five to six thousand feet under the same latitude, or perhaps even rather cooler. During this, the coldest period, the lowlands under the equator must have been clothed with a mingled tropical and temperate vegetation, like that described by Hooker as growing luxuriantly at the height of from four to five thousand feet on the lower slopes of the Himalaya, but with perhaps a still greater preponderance of temperate forms."

In view of the other evidence for elevation at the time that Darwin

*Hilgard, E. W., "On the Geological History of the Gulf of Mexico." Am. Jour. Sci. and Arts, Ser. 3, vol. ii, 1871, pp. 391-404.

†Darwin, Charles, "Origin of Species," Levant Ed. p. 371.

had in mind it seems proper to include all of this as evidence pointing to the conclusion that all of these tropical lands stood in greater relief above the sea than they do now to the extent of 5,000 to 6,000 feet or even rather more. He is inclined toward the larger figures.

BRITISH ISLES.

Between the British Isles and northwestern Europe a land connection presumably Quaternary, is conceded by all. It may have existed through the greater portion of Tertiary time. The soundings in the surrounding waters together with the distribution of the freshwater fauna have yielded a fairly complete picture of the river systems that occupied the regions now covered by the English Channel to the south and the Irish Channel and Irish Sea on the west.* The fact, determined by Hull, that one of these drowned rivers where it crosses the edge of the continental shelf forms a very deep gorge indicates that the duration of the emergent state was of the same order of length as the others of similar nature elsewhere, which is to say, it appears to have extended over a very large part of Tertiary time, much like the cañon of the Colorado in North America.†

Scharff has brought out numerous instances in which both animal and plant forms were able to survive the Glacial Epoch substantially in situ, in England and Ireland even forms like the Bristle Fern and many Portugese ("Lusitanian") species which normally enjoy considerably milder climates than even that of Ireland today. Under older notions of the Glacial Period it was deemed impossible that there should have been any such survivals in the British Isles, but they are clearly there. Scandinavian, Lusitanian, Amercian and even South American forms which must have been there long before the Glacial Epoch and which, if they had been swept off by the ice, could not have returned. Here in America we have a similar set of facts, excepting that here they are far more complicated by reason of the greater area and consequent greater probability that forms swept off toward the south could and did return northward when the ice disappeared.‡ Even here, in spite of Professor Gray's classical conclusions, it would afford relief from certain puzzling questions if we could find a refuge along the Atlantic coast for the fluviatile animals which now occur in the eastern mountain streams. It is inconvenient, to say the least, to be compelled to crowd these animals out with the glacial ice and then afterward to get them all back again apparently as they were before. It would be a good deal easier to lengthen their rivers a bit and let them take refuge in the lower altitudes while the ice was at work upon the heights. This is precisely what seems to have occurred in the British Isles. There we are almost compelled to infer that during the Glacial Epoch there was a much greater altitude of the land above the sea than there is now and that the explanation of the persistence of warmth-loving preglacial forms of life lies in the refuge afforded by a broad

*Scharff, R. F., "The History of the European Fauna," Lond. 1889.
"European Animals: Their Geological History and Geographical Distribution," Lond. 1907.
"On the Evidences of a Former Land-bridge between Northern Europe and North America," Proc. Roy. Irish Acad., vol. xxviii, Sec. B, No. 1, Dublin 1909.

†Dutton, Clarence E., "Tertiary History of the Grand Canon District," Monograph, U. S. Geolog. Survey, 1882.

‡Gray, Asa, "Forest Geography and Archaeology," Am. Jour. Sci. and Arts, vol. xvi, 1878, p. 94—, p. 183—.

strip of lowland surrounding the main, which afforded satisfactory climatic conditions to the forms driven down from the heights. The same would be true in the tropics, even though glaciation did not supervene. If, as according to Darwin's view, the isotherms were shifted down, or the land up, amounting to about the same thing, to the extent of only about 5,000 or 6,000 feet, which would permit the growth of a mixed temperate and tropical flora, there would presumably still remain heat-loving forms that would need still lower levels with greater warmth for their survival in the struggle for existence, so that in the tropics as well as in the northern climes there is need for low and warm borders to the continents coexistent with the general elevation. Refuges may be needed not only from glacial cold but from relative cold.

EAST INDIES.

Sumatra, Java, Borneo and the Malay Peninsula are separated by shallow seas. Their plants and animals are almost as closely related as if they were still connected.* Never-the-less there are not lacking many specialized forms which are restricted to particular islands and which argue for a reasonable lapse of time since the connections were inundated. If we view these islands in the light of much external evidence we find nothing which need oppose the theory that their (relative) depression dates as far back as the end of the Glacial Epoch.

Dr. Wallace treats the lowering of these islands as a purely local problem and thinks that it was caused by the extrusion of lava from under the earth's crust. There are several objections to this theory but they do not demand discussion here. We may say that this is only one instance among similar ones of the drowning of land connections all over the world and that this drowning is, like all the rest, related to the submerged borders of all the continents and is to be treated not as a purely local problem but in its proper relations.

MID-PACIFIC.

Upon the map, Figure 5, one more region of drowning remains to be touched upon. Pilsbry† found the freshwater and land mollusca of the mid-pacific islands sufficiently closely related to force the conclusion that they have been elaborated in areas much greater than they now possess and that their habitats were confluent. But this is nothing new, it has been argued for years that the Pacific islands are only the peaks of extensive regions formerly land and now drowned. If the molluscan relationships went back as far as the Mesozoic we might have to pass the region by in the present connection but they are said to be much more on the order of the late Tertiary and early Quaternary, at least between the various islands of particular groups. In general it is a development from primitive groups which cannot be traced to continental affinity later than the Mesozoic.‡

There are a number of problems in the Pacific whose solution seems

*Wallace, Alfred R., "Malay Archipelago," 1869.

†Pilsbry, H. A., "The Genesis of Mid-Pacific Faunas." Proc. Acad. Nat. Sci., Phila. 1900, pp. 568-581.

‡This paragraph is unsatisfactory to the writer and yet there seem to be reasons for leaving it as it is. Comment is cordially invited.

nearer upon the hypothesis of greater extent of land at a time later than the Mesozoic.

As showing the wide distribution and supposed simultaneity of many lost land connections, Figure 6 is copied, with a few omissions, from Osborn's "The Age of Mammals."* It may be passed over without particular discussion as merely serving to express the kind of belief which is current in very numerous and very scattered drowned land connections which existed and disappeared together in connection with the Glacial Epoch. Probably no two palæogeographers are agreed as to all details, as might be illustrated by maps from Ortmann, Matthew, Willis and others but they have enough in common to warrant us in basing further study upon their general features.

And now, in closing the presentation of the evidence both geological and biological I combine all that has been offered upon one map, Figure 7, to bring forcibly before the eye the fact that we are face to face with a world-wide problem of a scientific importance which can hardly be overestimated. If the elevation of the lands above the sea was as wide-spread as is indicated upon this summary map, or even anything approaching it, and if the necessary correlations may be made, it is difficult to avoid the inference that it in reality covered the whole world and that all that is lacking is more information. Now that additional information, and it throws light upon the correlation, may be considered to be supplied in the existence, around all the continents, of the submerged border so often alluded to. For convenience it has been omitted from Figure 7 but if we are to admit it in evidence on a par with what we have discussed, the continental outlines will practically represent it. We shall soon have occasion to recall what the leading geological thinkers hold as to the unity of this feature and therefore as to its admissibility as evidence in such a connection as the present one.

In turning now, to an analysis of the data presented, the points which it is important to carry with us are: land-elevation of world-wide extent, to the height of a mile or more above the level of the sea, an elevation of as yet indeterminate duration, an elevation which disappeared all over the globe at a time corresponding to about the end of the Glacial Epoch.

EPEIROGENIC MOVEMENTS VERSUS EUSTATIC.

We are dealing with movement. Was it movement of the land-masses, or of the sea, or of both? Prior to the time of Sir Charles Lyell it would more likely than not have been set down as fluctuation of the level of the sea. Since his time the thing is reversed so that for the most part such phenomena have been attributed to vertical movement of the land.

In 1868, Shaler† argued that movement of coast lines is not conclusive evidence of similar movement of the continental areas. He regarded the continents as great folds, not horsts with fractured margins, and the marine areas were areas of subsidence while the folds always tended to bend upward. Between the sedimented and therefore

*Osborn, Henry Fairfield, "The Age of Mammals in Europe, Asia, and North America." 1910.

†Shaler, N. S., "On the Nature of the Movements Involved in the Changes of Level of Shore Lines." Proc. Boston Soc. Nat. Hist., vol. xii, 1868-1869, pp. 128-136.

sinking sea bottom and the denuded and upfolding continent Shaler pointed to a fulcrum of no vertical movement, the position of a particular bit of coast with reference to this line determining whether it stood still or shared in the marine depression on the one hand or in the continental elevation on the other. Since the position of the fulcrum need by no means be constant it is evident that this theory introduces a maximum of heterogeneity into the relations between the continental margin and the sea.

While such action as was thus accepted by Shaler cannot be wholly excluded, and must fall into place as of possible local importance, it is not able to account for the major phenomena under discussion. The reasons for this are best stated by Suess and Chamberlin and they are freely quoted below.

The confidence in land movements started out with the conspicuous Lyellian merit of being in harmony with the facts of elevation and subsidence as actually observed and measured on various coasts. There seemed to be no reason why, given time enough, the observed movements should not go on to values such as we have been engaged in compiling. Leading in the same direction too, was the conception of a rather rigid crust collapsing irregularly upon a cooling and shrinking spheroid. All went well on these lines as long as the vertical movements remained local and isolated so that when one region rose another might experience a compensatory fall. Then came more extensive explorations and the knowledge that the vertical movements of greater degree are related over wide areas of the earth, and we find Professor Suess* remarking that "the theory of secular oscillations of the continents is not competent to explain the repeated inundation and emergence of the land. The changes are much too extensive and too uniform to have been caused by movements of the earth's crust," and again, "movements (like these) which present themselves as oscillations and extend around all coasts and under every latitude in complete independence of the structure of the continents, cannot possibly be explained by elevation or subsidence of the land. Even as the transgressions of the ancient periods are much too extensive and uniform to have been produced by movements of the lithosphere, so too are the displacements of the strand-line in the immediate past." This clearly bears upon the question of correlation and its effect upon Shaler's theory is evident.

Reade,† in 1903, is still groping for the light for he says: "None of the continents are now at their maximum height above sea level. Is it that the geographic forms of the spheroid are in less relief now than formerly, that the continental plateaux have subsided, or that the sea and ocean beds have risen? It is difficult to believe that the continental movements can have been coincident and universally in one direction all over the globe. It may be that in the vertical slow oscillations to which —the whole crust is subject, one land area has moved vertically upwards while other areas subsided, and it happens that none of the continents are now at their maximum elevation. The remarkable fact that the borders of all the continents, where sufficient soundings have been taken, show undoubted indications of having been formed by subaerial denudation, is a proof that at least portions of the land consti-

*Suess, Eduard, "The Face of the Earth," Eng. trans. vol. ii, Chap. xiv.
†Reade, T. Mellard, "The Evolution of Earth Structure," 1903.

tuting the present continents have been in times past at a much greater elevation above the sea-level than they are now."

Upon this point it is of interest to compare Chamberlin,* 1909. (page 688) "In the course of geologic history sea-transgressions and sea-withdrawals have constituted master features." "If heterogeneity had dominated continental action in the great Tertiary diastrophisms, the results should stand clearly forth today. Some continents should show recent general emergence, while others should show simultaneous general submergence. The dominant processes today should be those of depressional progress on the one hand and those of ascensional progress on the other. As a matter of fact all the continents are strikingly alike in their general physiographic attitude toward the sea. They are all surrounded by a border-belt overflowed by the sea to the nearly uniform depth of 100 fathoms. These submerged tracts are all crossed by channels, implying a recent emergent state. None of the continents is covered widely by recent marine deposits, and yet all show some measure of these. Wide recent transgressions in one part do not stand in contrast with great elevations in another. Even beyond what theory might lead us to expect, when we duly recognize the warpings incidental to all adjustments, the recent relations of the continents to the seas conform to one type. The 10,000,000 square miles of continental margin, now submerged is distributed around the borders of all the continents with a fair degree of equability."

We see thus, that there are very great objections to the theory of widespread epeirogenic movements as the main cause of the facts which we have passed in review. The only alternative is some form of marine movement and it seems difficult to understand why Professor Suess is opposed to this also. After emphasizing at length the importance of his eustatic movements, and after remarking that while the negative marine phase is clearly marked in the geological record the positive movement is masked, after all this and more, he rejects the idea that a positive movement is indicated by the peculiarities of the submerged continental margins. He practically admits the difficulty in detecting the positive movement, and he says: "If there were any reason to suppose that the quantity of water existing on the surface of the planet is not constant but subject to increase or decrease, as a result of general causes whether telluric or cosmic, then the resulting phenomena would fall within the category of eustatic movements." A reasonable inference from this is that while the facts cannot be really met by the epeirogenic theory, the alternative is so fraught with disturbing consequences that a man of Professor Suess' greatness shrinks from its embrace. The temerity then, of one who ventures too close to the sea to avoid the difficulties of the vertically moving land is sufficiently apparent.

In his able reviews of the epeirogenic theory, Upham attributed the elevation of the continents to tardy crustal yielding under secular cooling and contraction. The break-down he laid to the weight of the ice. North America, on this hypothesis, was held up by tangential pressure a mile, more or less, above normal, and in addition carried the weight of the glacial ice. That is surely very tardy yielding indeed. Suppose there were a mile of ice, that corresponds in weight to something like

*Chamberlin, T. C., "Diastrophism as the Ultimate Basis of Correlation." Jour. of Geol. vol. xvii, 1909, pp. 685-693.

a third of a mile of continental rock. That would be a heavy load to be carried by a crustal sheet which was already 3,000 to 5,000 feet or more above its normal level. If crustal yielding were so very tardy as that it is hard to understand why other sheets, all over the world, should yield at anything like the same altitude or at the same time.

The pendulum investigations of isostasy* have shown that the deviations from normal altitude with respect to mass are more properly expressed in hundreds of feet than in thousands. In general, isostatic balance is found to be nearly perfect, that is, within a very few hundred feet.

Again, while formerly much reliance was placed upon the shrinkage of the cooling earth, that source of crustal motion is now known to have been greatly overrated.

Ice-weighting can hardly be invoked to explain the supposed sinking (3,000 to 5,000 feet) on the coast of California because that was outside the region of general and heavy glaciation, but mountain-making occurred near by at about the same time that the sinking is thought to have occurred and might perhaps be adduced in explanation. That mountain-folding does produce depression is expressed in numerous foredeeps the world over.

Admittedly one of the best-determined cases of river-drowning, is that of the Congo, 6,000 feet. In this instance neither ice-weighting nor mountain-weighting can have played any part, and through very long geological time Africa has been subject to loss of mass through sub-aerial denudation, which ought to make it a rising continent rather than a sinking one. Africa itself presents absolutely no explanation of the submergence of the Congo cañon, especially in connection with the rest of the submerged margin, and unless we are able to reject the conclusions of isostasy, to which it is unlikely that many, at least of American geologists, will agree, we shall find ourselves compelled to boldly accept a eustatic positive movement as the explanation and done with it.

Again as to the depression of the glaciated lands by the weight of the ice; the density of the continental masses being not far from three, (water as unity), it would take about three miles of ice to depress the continental mass one mile. While there may possibly have been that much ice, or more, at some places, during the Glacial Epoch, it would seem to be an excessive figure for most of the glaciated area. From a half to one mile would probably be nearer the truth.

The upward movement of the strand cannot be accounted for by deformation of the lithosphere because since the oceans are thrice as extensive as the land, if all the lands on earth were depressed a mile and there were no submergence at all, no overflowing, so as to get the maximum amount of displacement, the ocean could only rise a third of a mile while all along the east coast of the Atlantic we have well over a mile to account for.

Nor have we, under isostasy, any true observed cause for such de-

*Putnam, G. R., "Results of a Transcontinental Series of Gravity Measurements," Phil. Soc. Wash. Bull., vol. xiii, 1895, pp. 31-60.
Gilbert, G. K., "Notes on Gravity Determinations by Mr. Putnam." Phil. Soc. Wash. Bull., vol. xiii, 1895, pp. 61-76.
Hayford, John T., "The Figure of the Earth and Isostasy." U. S. Coast and Geodetic Survey, 1909.
Willis, Bailey, "Principles of Palaeogeography." (section on permanence of ocean basins) Science, N. S. vol. xxxi, Feb. 18, 1910, pp. 243-246.
Willis, Bailey, "What is Terra Firma? A Review of Current Research in Isostasy." Ann. Rep. Smithson. Inst. 1910, pp. 391-406.

pression anywhere except ice- or mountain-weighting and sedimentation, and these are available over but a comparatively small part of the area.

No amount of deformation of the lithosphere under the oceans alone can alter the case; the only way to raise the general level is to submerge something that was not submerged before. Oscillations, as distinguished from alterations of general level, will receive attention in a moment.

So, in conclusion, it may be said that while one may sympathize with Suess' reluctance to accept change of ocean level as the cause of the world-wide drownings and may freely admit the necessity for caution in venturing to follow where that explanation leads, still, there are only two alternatives, land-movement or water-movement, and between the two one cannot be blamed for accepting the latter. We need not fail, at the same time, to recognize that land-movement is an actual observed fact. It is merely that it is not a satisfactory explanation of the greater phenomena of altitude of land and sea, over great areas, such as the deep drownings we have noticed, the great continental depressions, all apparently closely related in point of time.

CHANGE OF SEA-LEVEL, THE VOLUME REMAINING CONSTANT.

Accepting the doctrine that the world-wide loss of elevation on the part of the land as compared with the sea, which occurred at about the end of the Glacial Period, is to be accounted for mainly, not by vertical movement of the land, but by change in the level of the water, we have again two lines which we may logically pursue. Did the volume of water remain constant or did it change? Was it a displacement, or a phase of oscillation, or what?

The formation of ocean basins, as Suess remarks, is productive of lower level, and their obliteration by sedimentation or by crustal wrinkling under any form of the theory of the contraction of cooling must lead to the reverse effect. The worst objection to the wrinkling is that it is wholly inadequate for any such values as the evidence imposes.

It is entirely presumable that in the earlier geologic times, as distinguished from the Tertiary and recent, sedimentation played a more important role. As the land wore down, the seas, more of epicontinental type than now, and shallower, were displaced. Even then, however, one naturally wonders how such diastrophic processes would operate. The denuded lands ought presumably to rise, and the heavily sedimented marine areas ought to sink, and a permanency of the greater depressions is the logical result. Chamberlin* favored this idea in his theory of the formation of the now existing ocean beds, but there are the gravest sort of objections to the present day application of the theory however acceptable it may be, say for Mesozoic time and even then we have seen how Suess points out its inadequacy to account for the greater marine features.

Under present conditions diastrophism cannot possibly be the dominant cause of any such great rise of sea level as is indicated by our observed drownings, the continental areas to furnish the materials are only about a third of the area of the oceans.

Suess has discussed the attraction which the lands exert upon the marine waters,' and the piling up of glacial ice, though this is very

*Chamberlin, T. C., and Salisbury, R. D., "Geology," 1906.

questionable, might be regarded as tending to increase this attraction; and it would seem that an increased relief of the lands above the sea must surely also increase it. While all such considerations as this ought to be kept well in mind in any attempt at an impartial investigation, it is not apparent how this element of gravitational displacement can affect the problem of rise of ocean level. The most that would have to be considered would be fluctuations in the amount of it and if we had to take the whole it cannot amount to much.

Another idea coming under the head of displacement is the possible filling of ocean areas with extraneous material. Suppose we accept Professor Chamberlin's planetessimal hypothesis and the earth receives a marked addition of mass in the form of planetessimal or meteoric matter. There might be a readjustment of the relations of the land to the sea whether the increment happened to alight mainly on the oceanic areas or on the land. If it partially filled up an ocean bed, the newly acquired mass, by depressing its own area and causing a compensatory rise elsewhere, might partially offset its own first effect as a raiser of sea level. No such large accession of mass is recognizable at the present time. We cannot too lightly throw aside anything that even resembles a possibility and geological literature is not wholly lacking in suggestions of this very kind, but it does not seem that we need hesitate to exclude this kind of displacement as an explanation of the change of level to the extent of thousands of feet at the period in question, with just one possible exception. I am not aware that any particular restrictions have been imposed upon the chemical composition of the planetessimals. If the earth has been built up by accretions of mass from interplanetary space there does not seem to be any good reason why we must not suppose that the water came the same way as the other materials. And if it did, when was that? And just how much of it came at any one time? How are we to exclude such a possibility? That will have to be taken up again in a moment.

There are two theories of marine oscillation which require mention. Croll* in 1875 believed in alternate north and south glaciations with shifting of the earth's center of gravity and pole-to-pole oscillation of the sea, high level of the ocean coinciding with glaciation. There are two apparently fatal objections to this theory, at least in-so-far as it applies to ocean level; first, there is abundant evidence that the glaciation of the northern lands coincided not with a high-water but with a low-water phase; and second, in the course of pole-to-pole oscillations of the sea the tropical zone must be expected to be a region of minimum vertical movement. The facts are that the measures of the drowning in the tropical zone are well up to the general standard.

Suess'† theory of marine oscillation is that from some cause yet to be assigned there are alternate accumulations of water at the poles and at the equator. This might be connected with ice-attraction with bipolar glaciation but that explanation is not adequate for the large values obtained. Since the figures of both the hydrosphere and the lithosphere are dependent upon the rate of rotation, and we can find no indications of any considerable change in the rate,‡ it is very hard

*Croll, James, "Climate and Time in their Geological Relations." 1875.
†Suess, Eduard, "The Face of the Earth," Eng. trans. vol. ii, p. 563.
‡Chamberlin, T. C., "Former Rates of the Earth's Rotation" etc., In "Tidal and Other Problems," Carnegie Institution, 1909.

to justify such a theory and moreover it is open to an objection similar to that brought against Croll's theory, namely, that in oscillations between the equator and the two poles there would be two zones of minimum fluctuation. These might be looked for reasonably, in the neighborhood of the 45th parallels of latitude. As it happens, this parallel, in the northern hemisphere, passes through the Bay of Biscay where less than two degrees to the south, we have one of the best-determined and deepest instances (outside of the extremely high figures for the Antillean region) of a drowned river, 9,000 feet. Further to the north, in about 50 degrees of north latitude, Hull found one of 7,800 feet.

Change of the axis of the earth with respect to its contour has been discussed time and again and apart from all the mathematical reasons that have been urged against the suggestion it is open to the same sort of objection, that it cannot account for the Postglacial submergences which extend over all latitudes and longitudes as far as we can determine.

We shall have then to exclude, in searching for an adequate explanation, displacements, changes in the lithosphere, and fluctuations or oscillations either from pole-to-pole or between the poles and the equator. We must therefore reject the idea that the volume of the ocean remained constant.

CHANGE OF SEA-LEVEL INVOLVING CHANGE OF VOLUME.

Relying upon simple reasoning, we must conclude that the volume of the oceanic water has varied, and varied widely enough to explain, for instance, the 6,000 feet of Congo drowning.

The rise of the ocean to some such value or more would doubtless be an adequate explanation of the termination of the Glacial Epoch in the same way and to the same extent that the depression of the land to a similar degree has long been held to be sufficient. It would be merely a question of just what height was necessary for glaciation to begin. In the matter of climate the elevation that counts is not distance from the earth's center but distance above the prevailing surface, that is, altitude above sea level.*

Such an increase of ocean volume would presumably produce a differential elevation in the land masses by water-weighting of the oceanic areas of the lithosphere, so that a tendency toward the recovery by the land of some of its lost altitude relative to the sea must be filed as an offset against any increase of oceanic volume. Such a eustatic negative tendency following a positive one would be comparable to the elevation of the Terrace Epoch following the depression of the Champlain. Where the land was laden with ice the relief upon melting would operate in the same direction, tending to give higher values to this late recession of the strand. This is in harmony with the postglacial epeirogenic movements which are well known to have occurred in northwestern Europe and in glaciated North America.

*Mr. Frank Leverett, in discussion, mentions that the evidence indicates that during the melting of the last stage of glaciation there was only a gentle slope from the ice-front southward to the Gulf of Mexico. Earlier, as Hilgard pointed out, there are signs of a much higher gradient. This harmonizes with the trend of the present inquiry. Whatever causes may have operated to produce fluctuations in glaciation, the epeirogenic theory contemplates the final melting as being due to relative change of altitude. The gentle Mississippi gradient referred to by Mr. Leverett may represent the change to Champlain conditions.

Without pretending to anything minute in such a matter we may get some idea of the probable values of such movements by viewing the relations of the masses involved. If the specific gravity of the continental masses is three times that of water the land will tend to rise one-third of any theoretical rise of the ocean due to increase of volume. Supposing perfect adjustment, a mile of water laid on over the oceans would give 1,760 feet of compensatory, isostatic, elevation of the land. If the density of continental materials be placed at only 2.75 the result is somewhat greater, 1,920 feet. There is a certain usefulness in such figures, they give the idea that even with imperfect isostasy the compensatory elevations would very likely be of no mean amplitude and cannot at all be disregarded. There is good opportunity for thought here, in contemplating a possible relationship between the changes on the part of the sea and the Champlain depression and Terrace reelevation on the part of the land.

Now, we may well ask, what are the possible causes of change in the volume of the oceans? And how effectively do they fill the place that we have been preparing for that great cause that shall adequately explain the phenomena under consideration? There are five or six, as far as I can learn, of which Suess considers two, the formation of new mineral silicates lessening, and volcanic eruptions increasing the volume. The first of these may of course be omitted altogether in searching for causes of *rise* of ocean level; the second cannot possibly play an important role. Most of the water emitted by volcanoes is only that which has collected in craters or seeped in through fissures in the rocks.

There are other causes, that Suess does not mention, which may well be carefully reviewed. Heat, both solar and terrestrial, might play an important part and glaciation also. Let us take first solar heat, or rather, fluctuations in it, as a possible cause of changes of ocean volume.

Variation in orbital eccentricity, while changing the character of our seasons, cannot alter the amount of heat annually received from the sun; it has however, before now, been attempted to account for the Glacial Epoch by postulating changes in the amount of heat emitted by the sun, and in-as-much as more heat absorbed would convert more oceanic water into vapor and a lessening of that heat would permit recondensation, this factor, while it cannot be given rank as an established true cause still deserves mention as a possible theoretical cause of change of ocean volume. The Glacial Epoch being accepted as a time of land-elevation or sea-level depression, and its termination being coincident with the reversal of that condition, we should have to attribute the glaciation to heat and its disappearance to chilling because the sun radiated less heat to be absorbed by the earth. This paradox, however, might not be as improbable as it sounds, and Professor Frankland,* in 1864, presented considerable argument to prove a closely related proposition, namely, that the real cause of the Glacial Epoch was an oceanic temperature, due to terrestrial heat, higher than that of the present day. A similar idea was emphasized by Professor Tyndall. Frankland did not overlook this important difference between the two ideas, (solar heat and terrestrial) that warm oceans need not neces-

*Frankland, E., "On the Physical Cause of the Glacial Epoch." (The London, Edinburgh and Dublin) Philosophical Mag. and Jour. of Sci., Ser. 4, vol. 27, 1864, pp. 321-311.

sarily warm the land but a warm sun certainly must do so to the end that the snowline would be elevated and glaciation be made less possible. It would seem that this one point must be sufficient to exclude increase of the sun's heat as the cause of the low ocean level at the time of widespread glaciation.

As to terrestrial heat, Frankland argued that glaciation resulted at what might be called a critical stage of slow earth-cooling. He conceded that very warm oceans would lift the snow-line and render glaciation impossible; and he claimed also that oceans as cool as ours today would furnish so little atmospheric moisture to be precipitated as snow that the glaciers would be no longer fed and would shrink to the dimensions observed today. This is very hard to accept in view of the abundance of precipitation which most of our lands enjoy. The mountain glaciers now in existence all over the world do not seem to be seriously limited by lack of snow, but they are very sharply limited by altitude. However, between these two stages he introduced a third wherein there was an oceanic temperature higher than the present, but not too high, and by greater evaporation and resulting greater cloudiness and precipitation he thought to get a lowering of the snow-line sufficient to account for the phenomena of the Glacial Epoch.

All this is rather ancient history to the geologist of today and need not have been mentioned except for the fact that the first and second propositions referred to at the beginning of this paper would have supplied Professor Frankland with a seemingly important additional resource. Under those propositions a large amount of terrestrial crust was supposed to have been removed and the new-formed ocean-beds were but highly heated material with water pouring down upon them from the continental plateaux, the water cooling the new beds at the expense of its own liquid condition. For some time after such an event we should have to picture to ourselves oceans with hot floors gradually cooling. At the outset the ocean level instead of being low would be absent. At the same time the amount of heat reaching the land-surfaces from the interior would be no greater than it was before, and cloudiness and precipitation would doubtless be excessive. Slowly, the ocean must cool, its level rising as evaporation diminished. We may agree with Frankland that the enveloping of the earth in vast volumes of warm vapor, the atmosphere being more dense accordingly, must necessarily give higher temperatures over all lands. While the high differential altitude of the land would have a decided refrigerating effect, it is not at all likely that the then elevated line of perpetual snow would be reached by anything like the mean level of the lands which were covered with ice in the Glacial Epoch. When the water did ultimately condense again and come to the present oceanic depths we should reach conditions like the present ones, which Frankland considered to have terminated the glaciation. Now on the way from the initial hot state to the present cool one, he would have argued, there would supervene a stage wherein there would be altitude enough of the lands above the sea to permit, and at the same time atmospheric moisture and cold enough to produce, glaciation in the higher latitudes and higher altitudes. Here we should have our paradox again, the Glacial Epoch being dependent upon oceanic heat for its origin and oceanic cold for its termination.

Frankland cited Forbes' table of the altitudes of snow-line in Scan-

dinavia to show how the line falls passing from the interior, where the mean of six latitudes is 4,233 feet, to the coast, where it is only 3,566 feet. While these figures for Scandinavia may be correct as far as they go, they do not really meet the objection that the Gulf Stream, carrying warm ocean water to the British Isles makes their climate much milder than that of Labrador which is in the same latitude on the other side of the same ocean, while as between the two sides of North America the western enjoys a much milder climate as a result of the ocean in its vicinity being warmed by the Japan Stream. Similarly, in the southern hemisphere, we may note the fact discussed by Darwin* that the Antarctic Current gives the islands of South Georgia an almost glacial climate, with fauna and flora to match, as contrasted with a riotous vegetation on Terra del Fuego in the same latitude. South Georgia is considerably nearer to being permanently glaciated than is Iceland although the latter is ten degrees nearer the pole. But Iceland has the Gulf Stream. Conditions as actually observed indicate that cold oceans give cold land climates and vice versa, not that glaciation is produced by warm oceans.

But turning to differential altitude again it is evident that before the ocean cooled enough to reach the critical stage postulated by Professor Frankland, it must have approached fairly close to its present temperature and volume, so that the altitude of the land surfaces above it could play no important part in producing the Glacial Epoch. The excess of evaporation then over what it is now may be fairly assumed to have been largely taken up in the production of glacial ice, so that in that ice we ought to have a measure which would express by far the greater part of the deficiency of ocean volume below the present. We shall see in a moment that instead of indicating a lowering of the oceans or a rise when melting occurred, to the extent which our observational data demand, say 5,000 or 6,000 feet or more, the volume of water so fastened upon the land is wholly insufficient.

There are, therefore, several very good reasons why terrestrial heat, transmitted to the oceans, cannot be accepted as an explanation of such a low ocean level during the Glacial Epoch nor of the rise of the ocean to the height of a mile or more at the close of that epoch. The volume of the ice may be accepted as a fair approximation to the amount of fluctuation in the volume of the sea.

There is much geological reason for the prevalent belief that in Eocene time the oceans were considerably warmer than later, in fact that they continued to cool throughout Tertiary and Glacial time, so that if the earth were partially denuded of an outer cooled crust at the end of the Cretaceous period and the Tertiary opened with hot and shallow seas the record might read about as it does, there being a number of blank pages to start with because the first marine deposits would tend to be nonfossiliferous. That being the case, it does not appear to have taken all of Eocene time for the oceans to cool down to biological temperatures and in the remainder of Tertiary time they cannot have differed in temperature to a very marked degree from what we see today.

We have next to investigate the extent to which glaciation must be reckoned with as a modifier of ocean volume.

*Darwin, Charles, "Journal of Researches on the Voyage of the Beagle."

Tylor* thought that the ice-mantle lowered the sea 600 feet.

Belt† accepted Hartt and Agassiz' belief in glaciation in South America nearly to the equator, contemplated the large amount of evidence indicating a low level of the ocean during the Glacial Epoch and thought that Tylor's 600 feet would have to be increased to 1,000.

Upham considered the ocean surface as about 145,000,000 square miles and the ice areas of Europe and North America as 2,000,000 and 4,000,000 respectively, and put the thickness of the ice at a half or two-thirds of a mile, perhaps even a mile. This would mean between 218 and 219 feet of ocean lowering for one mile of ice over the glaciated area. Conversely the melting of this amount of ice would raise the general level a like amount. Some other cause would have to terminate the Glacial Epoch, the ice-water being merely an incident.

As suggested above, under isostasy the glacial ice must be conceived to have depressed its area, offsetting more or less the lowering of sea-level by abstraction, and conversely upon its melting the return movement must be reckoned with. This probable glacial lowering and post-glacial elevation cannot apply to regions lightly or not at all glaciated and cannot therefore alter the main conditions of the problem.

The melting of the glaciers from some cause other than change of altitude above the sea, and the consequent return of the ice-water to the ocean is not adequate to account for the increase of ocean volume which is demanded by the observed degree of submergence. For the oceans, with their area thrice greater than the land, to be raised a mile with reference to the land all the continents would have to yield the water of ice-mantles averaging three miles in thickness and for even this to be possible there must have been no isostatic depression of the lands under the load.

CONCLUSION.

We have now taken a fairly comprehensive view of the causes which have heretofore been suggested in explanation of the encroachment of the sea upon the land in Postglacial time. It has been possible, I think, to eliminate, one by one, all excepting the suggestion which was ventured that there might be such a thing as meteoric or planetessimal water. If the exclusion of one after another of the possible alternatives were less positive the case would be different, but nothing else seems to offer even a reasonable approximation to an explanation of the phenomena which await one. There is nothing inherently impossible in the suggestion that planetessimals gathered by the earth may once in a while include water enough to make considerable difference with the balance of things on the earth. Neither is there any need for denying that such an event or several such events may have occurred even as recently as Pleistocene time or the present day for that matter. It is by no means necessary to make such a conception dependent upon the acceptance of all aspects of the planetessimal hypothesis as at present developed. The arrival of cosmic materials upon the earth is a matter of common observation. The ability of water to traverse the interplanetary vacuum can scarcely be denied albeit that it may be advantageous to call upon

*Tylor, Alfred, Geological Mag. vol. ix, p. 392.
†Belt, Thomas, "The Naturalist in Nicaragua," London, 1874.

the low temperatures of space to freeze the errant water into planetessimals of ice. Hydrogen and oxygen might, for all we know to the contrary, come separately to the earth's atmosphere to be here combined. Water, liquid water, does constantly traverse space, see our own hydrosphere, held by the gravity of a planetary mass. Venus is supposed to be bathed in oceans. Comets may contain water in some form. Cosmic water must certainly receive some consideration.

The indications are strongly to the effect that prior to the end of the Glacial Epoch the earth possessed less water than it has had since, even allowing liberally for any amount that may have been locked up on the land in the form of ice. And the coming of water in sufficient quantity is surely capable of explaining the phenomena of the close of glaciation, the Champlain depression and the Terrace reelevation, just as the preceding lowness of sea-level is capable of explaining the fact of glaciation itself and the many land-connections which floral and faunal distributions demand. It thus becomes an eligible working hypothesis for a number of related problems.

It would not be reasonable to deny that other factors may have very materially influenced the same phenomena. Local movements, orogenic and epeirogenic, still have to be reckoned with; variations of orbital eccentricity, changes of ocean currents and other influences may yet be invoked to account for particular features. Other glaciations have come and gone in the course of geologic time and whether or not their causes were the same as those of the Pleistocene we may not positively say. Some of the influences considered in the foregoing analysis seem to be recognizable by their effects even though they are held to be inadequate for the main explanation. Underneath all else there is the persistent suggestion of some deeper, grander cause and it is that with which we should attempt to grapple.

The natural reference of these problems of altitude is to correlation, but insofar as correlation is to be based, as Chamberlin would have it, upon diastrophism, which in turn contemplates the relative altitudes of land and sea, it would seem that the groups of facts bearing upon these broad questions should be viewed collectively and that general conclusions should not be unduly hampered by preconceived ideas of correlation in particular localities.

Pending further discussion we may sum up the conclusions thus far obtained as follows:

1. During an undetermined period prior to the close of the Pleistocene Glacial Epoch there was a much lower ocean-level than there has been since.

2. At the end of that epoch there was an increase in the volume of the oceans so that the general level rose several thousand feet, probably a mile or more.

3. In the present state of science it is impossible to account for this increase of the ocean on the basis of the previous existence of the excess on or about the earth.

4. A natural inference is that the increase resulted from cosmic causes which, for the purposes of the present paper, may be left in general terms.

MAP OF THE OLD DISTRIBUTARIES OF THE ST. CLAIR AND DETROIT RIVERS.

BY F. B. TAYLOR.

Abstract.

The crest of the Port Huron moraine crosses the St. Clair River one and one-half miles north of the village of St. Clair. The moraine is waterlaid in this part and is a smooth, broad ridge, without the rough or hummocky expression of landlaid moraines. It rises to about 60 feet above the surface of the river and was an obstructive barrier in the first flow of the river. In its first flow over it the river made a number of shallow channels running southwest down the face of the moraine. Some of these are more than one-quarter of a mile wide, and others very narrow, mere creases in the surface. The master one of these streams cut deepest and soon robbed the rest of their water. This master stream flowed where the river now passes through the moraine. These first distributaries headed a little above the level of the Elkton beach. At the next, or Lake Algonquin stage, the river south from St. Clair was made up of two broad channels separated by a narrow gravel ridge. The ridge is an esker with its top toward its south end (west of Roberts Landing) fashioned into a beach. The river finally chose the channel on the east side and left the western one abandoned. The latter is now a swamp a mile wide extending from St. Clair nearly to Algonac.

In dropping to the Lake Algonquin stage the river cut through the morainic ridge at Detroit and through heavy bowldery drift masses between Trenton and Amherstburg. The cut at Detroit is simple, with no marked distributaries. It formed the gravelly, sandy delta at Delray with its head at the gravelly ridge at Fort Wayne in the west part of Detroit.

The distributaries around Trenton and Amherstburg and on Grosse Isle are particularly fine. The earliest, highest ones head northwest of Trenton and northeast of Amherstburg. They run southward to the lake independently of Detroit River. Most of them are now dry on the Trenton side, but some of those on Grosse Isle and on the Amherstburg side are now dead water canals, navigable for small boats. One of the most strongly marked and most recently abandoned channels starts at the south edge of Trenton and separates Slocum Island from the mainland. The Bay south of Grosse Isle was excavated mainly by distributaries of Detroit River in their later stages and partly when Lake Erie stood slightly lower than now.

SCIENTIFIC MANAGEMENT AND THE WAGE EARNER.

Efficiency programs are attracting much attention in this country at the present time because nearly all of the great expanse of land found within the borders of the United States has been taken up and the vast natural resources of the nation have been tapped. We are entering a period of diminishing returns; and a period in which increasing attention will be directed toward small economies that were not considered worthy of notice a generation ago. "The cream has been skimmed off the pan of our natural resources." Also, factory legislation, laws as to hours of labor and the activity of labor organizations are tending to raise the level of wages and to increase the expenses of operating a business. As a consequence, employers are being stimulated to adopt more efficient methods.

Many indications point to the conclusion that modern industrial nations are passing over the threshold of a new era in industrial and social progress. We are about to enter upon a period marked by the rapid increase in the use of machinery and of carefully planned methods of doing work,—witness, for example, the glass-bottle blowing machine, the giant mail order house with its systematized large-scale distribution of goods, and the farmer's use of engines drawing gang-plows. The term, "industrial revolution," has heretofore been applied to the rapid adoption of new tools and machines.

"Social invention" is to be typical of the epoch just ahead. And what may be tabulated under the head of social invention, efficiency engineering or scientific management? Efficient combinations of labor-saving machines, accurate information as to the time and energy required to do specific jobs, motion studies of different craftsmen, and psychological studies of the kinds of incentives which most effectively stimulate workers to do their work efficiently,—these are some of the important planks in the efficiency program.

Scientific management or efficiency engineering is concerned with two somewhat interrelated matters: 1. The efficient systematization of the work in a given factory from the engineering or the mechanical point of view,—the routing of the work, proper cutting speeds, the care of tools and machines, and the like. 2. The second factor is psychological in its nature; it relates to the effective methods of "energizing" the workers by providing potent incentives and stimulating interest in the work. The first is the more simple of the two problems but it cannot be carried out successfully without solving the psychological problem. Technical improvements in methods will be introduced as were machines of various kinds in spite of the opposition of the wage earners. But the second portion of the program of the efficiency engineer cannot be forced thru. It cannot be secured by coercion; it can only be effectively carried out when the wage earners harmoniously cooperate with the managers in working out the proposed plan. The fundamental problem of efficiency

engineering centers around the treatment of the wage earners. It is more a problem concerned with the relations existing between the employer and his employees than it is a problem of bookkeeping or of the care of machines or of the selection of tools. The pioneer and leading exponent of efficiency engineering, Mr. F. W. Taylor, writes: "This close, intimate, personal cooperation between the management and the men is of the essence of modern scientific or task management." And Harrington Emerson asserts that "to establish rational work standards for men requires indeed motion and time studies of all operations, but it requires in addition all the skill of the planning manager, all the skill of the physician, of the humanitarian, of the physiologist; it requires infinite knowledge directed, guided and restrained by hope, faith and compassion."

In theory, according to its advocates, scientific management stands for increased productive capacity without increased effort; it aims to do away with lost motion and useless movements. It means maximum results with a minimum of effort; it does not mean "frenzied production." Now, these objects are certainly worthy of approval. Opposition to efficiency engineering must arise because of the methods employed in carrying out the policy. Our attention evidently must be directed toward this inquiry: How, then, can this "close, intimate, personal cooperation" of which Mr. Taylor speaks, be secured?

It is perhaps worth while at the outset to call attention to the fact that the man who is "working for himself" does not object to methods or systems which lighten his work. The farmer is glad to get a tool which will increase his productivity. Even the conservative wife of the farmer is not adverse to the installation of a new or better pump, a cream separator, or some scheme which will save steps. Why then does the wage earner so frequently resist the introduction of new machinery or of new and scientific methods of performing work? The farmer and the farmer's wife do not fear that the new machines or methods will cause them to lose their positions, or that they will be called upon to do much work for little more pay. They believe, on the contrary, that their income will be increased and the length of their working day reduced. In short, they are confident that the results of their efforts will be multiplied. On the other hand, the wage earner feels instinctively, too often as the result of past experience, that the system of scientific management is some subtle scheme to advance the interests of his employer at the expense of the workers individually or as a class. How can the viewpoint of the worker be modified until it coincides in this particular with that of the farmer or with that of the man who is "working for himself"? This is another fundamental problem for the efficiency engineer to solve.

The wage earner, however, demands that a portion of his share in the advantages accruing from improved machinery and scientific management be given to him in the form of a shorter working day. His conception of a desirable form of society in the twentieth century is not one in which a certain number of individuals work long hours at high speed; but one in which all work during a short working day. There are obviously at least two alternative methods which may be pursued in producing a given quota of economic goods and services: a small number of men may be employed for a long working day or a larger number

for a shorter working day. From the viewpoint of the wage earner the second alternative is not repulsive. His ideal is not necessarily maximum productivity per worker per day; but a condition in which work and recreation are blended for each and every individual. And if economics is "the reasoned activity of a people tending toward the satisfaction of its needs," shall the economist calmly assert that the wage earner's ideal is one worthy only of contemptuous rejection?

Before passing to a consideration of the conditions which are requisite for the successful outcome of scientific management, it seems appropriate to notice some of the points made by Mr. F. W. Taylor in his recent book, "The Principles of Scientific Management." These points have a direct bearing upon the later discussion of the topic under consideration.

Mr. Taylor declares that under an adequate system of scientific management, "each man should daily be taught by and receive the most friendly help from those who are over him, instead of being, at the one extreme, driven or coerced by his bosses, and at the other left to his own unaided devices." In this manner, it is urged "systematic soldiering" on the one hand and injurious speeding-up on the other hand will be avoided. But is it reasonable to expect that the workers will willingly and contentedly leave the determination of the definition of systematic soldiering and injurious speeding-up to the inevitably prejudiced judgment of their employers?

The model workman from the standpoint of the typical efficiency engineer is the vigorous man who freely expends all of his surplus energy during working hours and who utilizes his non-working hours only for recuperation and preparation for another day's work. It is not the purpose of efficiency engineering to allow the worker to depart from the door of the factory at night with more than a minimum of surplus energy for recreation, for family life, for civic duties, or for trade union activities. In short, I find little in the actual program of efficiency engineering which indicates that the wage earner is to be given opportunity for individual development,—and I have not overlooked the various paternalistic endeavors classified as welfare work. A human machine rather than a man is the "model workman." I also find little, or more accurately nothing, in Mr. Taylor's book which indicates that he appreciates or sympathizes with the viewpoint of the wage earner.

Mr. Taylor informs us that a long series of experiments has shown that an increase in wages up to sixty per cent beyond the wages usually paid has a good effect upon the men. But, "on the other hand, when they receive much more than a sixty per cent increase in wages, many of them will work irregularly and tend to become more or less shiftless, extravagant, and dissipated. Our experiments showed, in other words, that it does not do for most men to get rich too fast." But what of the efficiency of the corporation which receives large increases in its rate of profits? How do such increases affect the alertness of the managers, the adoption of improved methods, machines and safety appliances? Can the workers or the consumers afford to allow an employing corporation to increase its rate of profits? If so, how rapidly and how much? This is an unworked field of efficiency engineering. And our efficiency engineers are not enthusiastically interested in investigations of this sort.

"Soldiering on the part of wage earners in the United States is

alleged to be a menace to the prosperity of every establishment and of every wage earner in the nation. The causes of soldiering, according to Mr. Taylor are three in number; but these are readily reducible to two. These two causes may be stated as follows: (A) the general acceptance of the lump-of-work doctrine; (B) the lack of scientific management. I have elsewhere[1] shown that the lump-of-work argument cannot be so easily laughed out of court as same economists and employers would have us believe. The workingman is interested in tomorrow's job and wages rather than in some indefinite benefit to society next decade. "The knowledge that a certain policy, if pursued by all for a period of years, will inevitably bring about reductions in the wage scale does not appeal to the average wage earner with a family to feed, clothe and shelter in the direct and forceful manner that the immediate probability of slack work does. He sees that by 'nursing' a particular job he may work longer or another fellow workman may be employed. This is something tangible, the other is a remote and uncertain possibility. Immediate work for John overshadows the vision of a chance of future employment for Tom, Dick, and Harry, and other unnamed and unknown individuals."

Mr. Taylor directs attention to the shoe industry. The introduction of machinery into this industry has undoubtedly cheapened the price of shoes to the consumer; and the workers can, as a consequence, afford to buy more and better shoes. And it may also be true "that there are relatively more men working in the shoe industry than ever before." But it is also a fact that many workers were adversely affected by the introduction of shoe machinery. That great and spectacular outburst of unionism,—the Knights of St. Crispin—was not the fantastic result of purely imaginary dangers. Many men with wives and children to feed, clothe and house, saw their trade, that is, their means of earning a decent livelihood, being ruined; they saw, and their vision was not defective, the menace at that time and place of cheap labor. Their problem was individual and immediate, not social and a matter of future welfare. Allow me to point out that this non-social lump-of-work argument is closely paralleled by what may well be called a lump-of-capital argument.

Many a corporation composed of individuals who are not in business for their health, has obtained a patent upon some new appliance which would cheapen the cost of production but necessitate the scrapping of much valuable equipment; and, consequently, with the aid of our antiquated patent laws such corporations have quietly shelved the patents. The attitude of the capitalist in such a case is not very dissimilar to that of the workman who opposes the introduction of machinery or of new processes which threaten his trade or his lump-of-capital. In addition to the prevention of soldiering on the part of workingmen one of the problems of a well-rounded program of efficiency engineering would be to prevent the shelving of new appliances and machines, and, perhaps, to call for a modification of our patent laws. But as far as my knowledge goes, our efficiency engineers have not paid much attention to this important matter.

With these illustrations before us, you are asked to direct your atten-

[1]The History and Problems of Organized Labor, pp. 132-134.

tion to the requisites, in the judgment of the speaker, for a successful form of efficiency engineering or of scientific management.

All careful and disinterested students of efficiency engineering will doubtless admit that such systems are advocated by the employer, that the employer instituting them expects to direct their operation, and that the systems are adopted primarily for the benefit of the employer. The problems connected with the various systems are viewed from the standpoint of the employer and capitalist. Benefit to the wage earner is perhaps considered to be an incidental advantage; but it is a secondary matter. The bright and shining goal—the attractive lure— is lowered costs and increased profits rather than better workmen and citizens, or more leisure and culture and enjoyment for the toiling mass and their families. Is it reasonable to expect that the wage earners, organized or unorganized, will grow enthusiastic over a lop-sided system of scientific management? If, as Mr. Taylor declares, "close, intimate, personal cooperation" is required to "energize" a plant, efficiency engineering cannot reach a high degree of success while the workers distrust the motives of the employer, or as long as the workers in the plant are convinced that the employer is trying to get more work out of them without proportionally increasing their pay.

The average American citizen looks askance upon an arbitrary government—a government which is in no way under the control of the mass of governed. The despot whether enlightened and benevolent or not, would be regarded with suspicion and would not be tolerated. Men have repeatedly and vigorously objected to arbitrary action on the part of government. And for centuries the western world has been moving toward democracy. The Louis XIV view of government is obsolete; but absolutism in industry is still characteristic of the business world. Will not, therefore, the average wage earner granted political privileges but shut out of the councils of industry, distrust the management of the business in which he earns his daily bread? He will certainly see in the plans of the employer schemes for quietly and effectively squeezing the laboring man. The workers in our shops, factories and mines can no more be expected to look with favor upon arbitrary changes concerning which they have not been consulted, than can the average citizen of today be expected smiling to abide by the rulings of an arbitrary monarch.

The day of the individual entrepreneur is of the past not of the present or of the future. We may regret his going, we may vociferously assert that he was superior to the giant corporation with its collection of mutually interdependent units, and we may argue that the rivalry between entrepreneur and entrepreneur is essential to business progress and industrial efficiency; but the corporation is here and here to stay. Likewise the day of individual bargaining with the isolated worker is passing. Employers may strive to delay its going; but in vain will be the effort. Professor Commons has pointed out that unorganized as well as organized workers are willing to strike for the right to bargain collectively. "It is their desperate recognition that the day of individual bargains is gone for them." It is safe to assert that efficiency engineering will not be successfully introduced and maintained by union-smashing corporations demanding individual bargaining with workers, —because "close, intimate, personal cooperation between the manage-

ment and the men" is impossible under such conditions. Efficiency engineering can only hope to succeed, in the long run, in energizing workers by utilizing the collective bargain. And accepting the collective bargain means the partial admission of the representatives of the workers into the councils of the employers. It is a tentative step away from autocracy in business management. Collective bargaining and the admission of the workers into the councils of the management is one of the essentials of close cooperation between the management and the employees. But the leaders in the movement have not given this fundamental fact definite recognition.

Successful scientific management—management which possesses the qualities demanded by its advocates—must necessarily cast aside the old incentives such as coercion, the constant nagging and prodding of the foreman; but, furthermore, it must be so directed that the workers will be convinced that it is to their interests to accept the planning-room's methods and program, and to follow the system outlined by the experts in charge of the work. But, if the past offers any useful lessons for the present, we are obliged, in my judgment, to conclude that the workers must unite upon the industrial and the political field in order to derive any considerable share of the benefits of efficiency engineering. Without united and aggressive action, the workers will be shorn of the major portion of the direct benefits of efficiency engineering. Mutual respect and cooperation between employers and employees are the fruits of equality in the strength and coherence of their respective organizations; and, indeed, only under such conditions can scientific management achieve its maximum of efficiency. And, it may be quite confidently asserted, that if under our present industrial order this kind of scientific management or of efficiency engineering cannot thrive, then is that order doomed to be displaced by socialism or some other form of industrial democracy.

In conclusion, it may be pointed out that the success of collective bargaining which has been asserted to be an essential element in successful efficiency engineering, in turn depends upon the solution of this basic problem: What is a fair wage? Or, more specifically, the question may be formulated in the following manner: What is a fair wage in an epoch when competition is being displaced as an effective force in the industrial world? Or, we may even go one step further: Is there a concept of a fair wage which can be made acceptable to both employers and employees? Concretely and specifically, the question may be stated after this fashion: Can a scientific basis be found for the determination of a satisfactory time base and a satisfactory premium rate for the various progressive wage systems which are being introduced by efficiency engineers? And, lastly, it may not be irrelevant to inquire: Can scientific management reach a high level of efficiency while approximately one-half of the adult wage earners of the nation are receiving not more than $500 per year? Students of workingmen's budgets seem to agree that in order to support a normal family in a decent manner an income of $750 to $900 per year is required.

In brief, these are the conclusions reached: (1) Up to date, efficiency

engineering has been a one-sided matter. (2) To be highly successful the cooperation of the men with the management must be secured. (3) Such cooperation can only be secured by utilizing the collective bargain and by admitting in some measure the representatives of the workers into the councils of the management. (4) And, still further, the success of collective bargaining depends, in the long run, upon finding some mutually acceptable basis for a fair wage.

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THE STATUS OF WORKMEN'S COMPENSATION LEGISLATION IN THE UNITED STATES.

It is a fact of no small significance that simultaneously in seven states of the Union—California, Kansas, New Hampshire, New Jersey, Washington, Massachusetts and Ohio—the several legislatures should have enacted Workmen's Compensation legislation in the year 1911. Similar legislation had been enacted prior to this date in Oregon, New York, and by the Federal Congress. This legislation is the product of wide spread belief in the necessity for radical reformation of our laws pertaining to accidents among workmen in our industries. Our legislative bodies have been very slow in recognizing the necessity for these laws. Several reasons contribute to their general awakening. (1) The number of accidents in industrial pursuits has rapidly multiplied with the consequent results of burdened courts, miscarriage of justice, and heavy demands upon charity. (2) Efforts to find solution by more stringent employer's liability laws have proven unsatisfactory. (3) The influence of other nations which have already taken this advanced ground.

A cursory examination of the laws of the several states reveals many similar features, as well as many diverse provisions. The diversity is due partially to the different industrial conditions in the various states. More especially is it the result of no unanimity of mind as to the best provisions of such a law. The model law is yet to be drafted and must be the result of an evolutionary process, in which different features must be subjected to trial, weaknesses detected and remedied, until an acceptable law is secured.

Before assuming the discussion of the particular features of these laws, it may be well to consider the definite purposes underlying these statutes. 1. Primarily, all seek to insure compensation for accidents, whatever may be the cause of the accident. (2) To save a considerable part of the present cost due to litigation. (3) To provide administrative tribunals where disputes between the two parties concerned may be adjusted promptly, cheaply and conclusively. (4.) To minimize the number of accidents of industry by automatic restraints. Reliable statistics show that three times as many persons in proportion to the number employed, are killed or injured in the course of employment in United States as in any other country of the world.

Parenthetically, we should remind ourselves of the requirements which the common law has necessitated on the part of both the employer and employe. The one is obliged to furnish a safe place for the laborer, to provide reasonably competent fellow workmen and subject all employes to reasonable regulations. The other is expected to exercise reasonable care in observance of such rules and to assume all ordinary risks incident to the business, as well as the negligence of fellow workmen. If an employe is negligent in any one of these particulars, he will not be able to recover damages even though at the same time the employer is

guilty of a breach of his obligations. These common law defenses, known under the familiar titles of "contributory negligence," assumption of risk" and "fellow servant rules," have been rendered less harsh and severe by many statutes pertaining to dangerous employments requiring the provision of safety devices by the employer, the neglect of which rendered the defenses of "assumption of risk" and "fellow servant" null, or at least materially modified. This type of legislation has been abundant in recent years. In Ohio, for instance, it was possible for a workman to recover through the courts for every injury except those arising in the use of simple tools or due solely to his own personal negligence. These precautionary measures were meritorious but not adequate to the necessity of the situation. American experience with this remedy is coinciding with that of England and Germany in that two objectionable consequences thrust themselves upon the public. It has multiplied the litigation in our courts through increased number of suits for damages, with all the attendant evils, and permits a large number—over fifty per cent—of cases where there is no neglect on the part of either party but due to industry, to go uncompensated. It is right here that the fundamental characteristic of the new laws appears. It aims to compensate the workman in *all cases*, regardless of the blame or absence of blame, except such injuries as may be due to wilful neglect.

There are certain fundamental features of these statutes which must be given attention in order that the matters provoking differences of opinion may be clearly established in our minds.

1. *Adoption of the Law.* In the majority of cases—New Jersey, Kansas, New Hampshire, California, Ohio and Wisconsin—it is optional with the employer and employe. The statute expressly provides that the employer may choose between the common law settlement, divested of common law principles, or compensation. In case the employer neglects or refuses to accept the law ,then the common law holds good with the three common law defenses abrogated. It is usually assumed that the employe accepts the law, unless he notifies the proper authorities of his refusal upon contracting his labor. The reasons for this optional feature are two. First, the law is so new and contains so many experimental and innovational features that legislators believe it wise to gradually introduce it. Again, some legislatures feared the law would be declared unconstitutional, with compulsory provisions whereby the common law is invalidated. Such states hope to overcome this outcome by requiring the employer to divest himself of the common law defenses as a penalty. In case of employes electing not to accept the law with an employer who has so accepted, the common law defenses remain in force. The courts of Massachusetts and Wisconsin have recently upheld these modifications in their states, which lends force to this feature and points toward the acceptance of this view.

A few states—Washington, Montana and New York—have made the law compulsory for hazardous industries, while others, as California and Wisconsin, do so for all state, county, town, village and school district employes.

2. *Sources and the administration of funds.* (a) Sources: With the exception of Ohio, which collects 90% of the fund from the employer and 10% from the employe, the laws provide for the entire payment by the employer. The considerations which underlie this provision are that

to tax the employe means the creation of the necessity for advancing wages of workmen, while it is contemplated that the employer may reimburse himself from the consumer. It is argued by some proponents of compensation laws that each party—workman as well as employer—should bear such share of the expense as his responsibility for accidents demands. It is difficult to see the feasibility of such a plan.

(b) Administration—Ohio, Montana, Massachusetts and Washington require the funds to be paid to the state, which becomes responsible for compensating the workman. All other states arrange for the payment to the workman directly by the employer, by rendering the employer legally liable for such payment.

Opinions are somewhat diverse with regard to this feature of the law. Eminent authorities pronounce state administration as the only effective plan, since it is the only means whereby the employe can be assured of his compensation. Otherwise he would be in jeopardy by possible insolvency of the employer. On the other hand this plan is weak, in that it absolves the employer of responsibility for the decrease of accidents. The consequent demands upon the state may make the payments a burden to the state.

The second plan, however, may bankrupt the employer, in which case the employe must suffer. It is proposed, in Michigan report, for instance, to permit the employer to protect himself by some kind of insurance either mutual or employers' liability insurance. This enhances the cost to the employer, but places on him the responsibility for reducing accidents to a minimum. The problem is to escape the evils of the bankrupt employer or corporation on the one hand and the insurance company on the other.

Administration of the law. The duties of administration are placed in charge of special boards or commissions created by the several acts. Wisconsin—Industrial Commission; Ohio—State Liability Board of Awards; Michigan—Industrial Accident Board (proposed); New Jersey—Employers' Liability Commission.

These bodies are constituted as tribunals in which all matters of dispute between employer and employe in regard to compensation shall be settled. This keeps such controversies from the courts and aims to secure uniformity of decision and administration as well as promptness and conclusiveness. As constitutional safeguards and a means of attaining justice provisions for appeal from the decisions of this tribunal to regular courts are made, but these differ. In Wisconsin appeal may be taken if the board has exceeded its powers, is guilty of fraud or makes an award not supported by facts. In Ohio appeal to courts may be made if award has been denied. Michigan (proposed) findings of Board may be reviewed by State Supreme Court upon application within a fixed time limit by aggrieved party.

The expense of administration is fixed upon the state, which can well afford to bear it, inasmuch as it is relieved by a considerable per cent—variously estimated as 25% or more—of its litigation. This may be defended, also, upon the ground of the vital interest which the state possesses in the welfare of the workmen and their families.

Schedule of Compensation. The states agree in having some compensation but do not agree in all the details of their schedules. For instance, in some laws the employer is required to furnish medical ser-

vices for a period after the accident. The considerations that demand this are obvious. The necessity for competent service, the probable better judgment of the employer, acquisition of authentic information, and the natural desire to minimize the results of injury, make this a wise provision.

The payments for injuries depend upon the seriousness of the injury and is fixed by schedule based upon wages of the workman, in most cases. In case of death the employer shall pay a per cent of the wages in weekly installments for a stipulated time, 300 weeks most frequently, with a minimum of $1,200 and a maximum of $3,000.

In case of partial disability the payments are a per cent of the wages, most usually 50%—65% in Wisconsin—for a stated period—say four years. Wisconsin advances these payments to 100% in case of permanent disability; Ohio two-thirds wages until death; New Jersey 50% for eight years.

In case of temporary disability the same principles are applied, with less liberal percentages. Frequently the law presents a fixed schedule of payments, graduated to the severity of the injury as measured by the part of the body injured—so much for loss of finger, or loss of hand, or loss of foot, etc.

Parenthetically, it may be of interest to note in this connection that the Federal Congress has a Workman's Compensation measure before it at the present time. This measure is modelled after the state laws, embodying what are considered the best features of such laws. Congress has already legislated in this field. The first act—1906—was set aside by the courts because not limited in its application to Federal jurisdiction. The second act—1908—has been sustained by the courts but is restricted in its application to common carrier employees while the act at present under contemplation will extend to all employees subject to the authority of the Federal government.

Finally we note that phase of our topic which is provocative of wide comment and discussion, i. e., the relation of these statutes to our fundamental law. The progress of this legislation has been impeded because in conflict with our rigid constitutions and their established lines of interpretation. We adapt ourselves to this new procedure less readily than do European nations. Recently the public has had its attention directed to this phase by court decisions in Washington, Wisconsin and New York.

The New York law was pronounced unconstitutional on the ground that the law violated the clause of the state constitution, as well as a similar clause in the United States constitution, which forbids the taking of property without due process of law. The court holds that to establish liability without fault is such deprivation of property and at variance with the common law principle. This same contention was raised with the Washington law, which was charged, also, with taking the property of one employer to pay the obligations of another. The court of that state upheld its validity under the authority of the police power of the state, which is that power of the state to regulate the affairs in accordance with public welfare in the absence of express prohibition.

The court cites numerous decisions in support of this contention. Of these we give only two. The court cites the Federal Statute whereby the owners of United States vessels may be taxed for each sailor em-

ployed on their ships. These moneys become a relief fund in the United States Treasury for maintenance of sick and disabled seamen.

Statutes making railroad companies liable for loss of property caused by fires set by their locomotives clearly create liability without fault. Such statutes have been upheld by state courts and by the Supreme Court of the United States.

The two decisions bring into conflict two fundamental principles of our constitutions. The one finds its justification in the protection of the personal rights in property, while the other involves the rights of the public, as well as personal welfare of the employed class. Obviously the issue concerns the definition and use of the police power, which cannot be discussed in this brief paper. This power is ample in all cases of dangerous industries. Whether it is sufficient to cover all kinds—the less dangerous as well—remains to be seen. The recent decision of the Wisconsin court makes use of this defense and brings the workmens compensation law of that state within the scope of its fundamental law. Reliance in this matter must be placed in the wisdom, sense of justice and broad constitutional vision of our United States Supreme Court finally. If a sense of justice and general welfare demand a change from the present system of employer's liability, surely under a rational constitution, ordained to establish justice and promote general welfare, it ought to be possible. Recent decisions and utterance of our highest court give evidence of this attitude. For instance, in the case Noble State Bank vs. Haskell, 219 U. S. 104, the court said of the police power, "It extends to all the great public needs," and "may be put forth in aid of what is sanctioned by usage or held by the prevailing morality or strong and predonderant opinion to be greatly and immediately necessary to the public welfare."

Again, in Holden vs. Hardy, 169 U. S., 366, the same court declared "that the law must adapt itself to new conditions of society." It may seem very reasonable that a conception of the police power which permits taxation of a banker to guarantee the debts of another banker ought to be comprehensive enough to include a workmen's compensation act. These views—even though the court be not called upon to render a decision immediately—will shape the judicial opinions of our state jurors.

Again, these laws are accused of interfering with the freedom of contract. Some states seek to avoid this charge by making the law optional for both employer and employe. In cases of compulsory law this provision is defended by resting it upon the police power. On general principles it is the right of every citizen to contract his labor or services. Yet, this is not an absolute right. There can be no doubt that the state can restrain some individuals from all contracts, and all individuals from some contracts. Some restriction upon contractional rights, of course, is very common. The basic test of whether this law comes within the scope of this defense is the reasonableness of the regulation. The fact that it is the means of attaining a social good as well as remedy for personal injustice the Washington court pronounces ample justification for upholding the law as valid.

This same line of defense is applied to the charge that such a law is a species of class legislation, because it takes property from one group

of persons and bestows it upon another. Nor does it violate the constitutional guarantee of the equal protection of the law to all persons.

Objections are raised to the classification of trades because the laws in many cases cover all trades and are not limited to hazardous ones. This cannot be a valid objection, because all trades in which accidents may occur are hazardous in some degree. Furthermore, the fact that employers dealing with less than three workmen are in some states exempt is defensible on the grounds that the dangers and means of avoidance under such circumstances are comparatively easy.

Another attack upon the Washington law is that it violates the provisions of the constitution which aim to secure uniform taxation for public purposes. The court denies the term tax as applicable to the provisions of this law. It does not involve a contribution to the government to meet the expenses of government, but is to recompense employes. It is a condition imposed upon owners for the privilege of carrying on business and is therefore in the nature of a license tax, imposed for revenue and regulation. As such it is not hostile either to the state or Federal constitutions.

Finally, these laws are assailed because they deprive the individual of his constitutional right to a trial by jury in case of adjustment for injury. The validity of this charge may be questioned for the following reasons. (a) The right to trial by jury is competent only when, under legislation provision, the individual is entitled to bring action for damages. These laws have removed the cause of action on the one hand and the ground of defense on the other and merged both in a statutory indemnity, fixed and certain. If under the police power the cause for action may be removed, their right to jury trial, being incident to the right of action, is left without anything upon which to operate.

(b) In many laws this right is presumed by allowing an appeal from the administrative board, or if not, then the board has conferred upon it the quasi-judicial power to determine facts. This is similar to the power of Boards of Health, etc. In case said board exceeds its powers or is guilty of fraud or abuse of its power, then appeal may be taken to the proper courts and the rights of the individuals concerned may be safeguarded by the acceptable constitutional method.

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RESULTS OF THE MERSHON EXPEDITION TO THE CHARITY ISLANDS, LAKE HURON.

THE AMPHIBIANS AND REPTILES OF CHARITY ISLAND.[1]

BY CRYSTAL THOMPSON AND HELEN THOMPSON.

This paper is based on the collections made by the various members of the Mershon Expedition of the University of Michigan Museum to the Charity Islands.[2] During the summer of 1910, six men were in the field, each of whom devoted his time to a particular group. In 1911 Mr. Wood again spent a few weeks on the island, Dr. Ruthven was there for a few days, and the writers were sent over in August to take photographs of the habitats and secure what data they could. Several papers have already been published[3] on the results of the expedition and others will follow.

The Charity Islands are a group of three small islands situated near the mouth of Saginaw Bay. The largest, Charity Island proper, on which the amphibians and reptiles were studied, contains about 650 acres of rock and sand, is owned by the United States Government, and is used as a light-house station. Cutting of vegetation, hunting, and fishing within a mile of its shores are not permitted, so the conditions are decidedly primitive. The island is covered with a natural forest of oak, maple and pine, there is a shallow pond comprising several acres on the west side, and the beaches are mostly low and sandy, with an occasional projecting point of bare rock.

Little Charity, containing about 3 acres, is used as a fishing station, and Gull Island, the smallest of the three, is merely a low projecting reef, about a quarter of an acre in extent, that is generally not indicated on the maps. The group is somewhat nearer the west coast than the east. Charity Island is six and seven-eighths miles southeast of Point Lookout, nine and seven-eighths miles northwest of Caseville and nine miles northwest of Oak Point.

The islands are of especial interest biologically in that they have not been connected with the mainland since glacial times. The presence of resident birds is of course easily explained, and the few mammals probably cross on the ice during the winter. There are two possible ways in which the salamanders may have reached the island. The young in the aquatic stage or the adults during the breeding season may have crossed by water; or, and this seems to be the more plausible explanation, the adults may have drifted over in decaying logs. The latter explanation may also account for the presence of the fox snakes, milk snakes, garter snakes and green snakes, and the toad and perhaps

[1]From the University of Michigan Museum of Natural History.

[2]The writers are also indebted to Dr. A. G. Ruthven for his notes on the reptiles and amphibians of Charity Island.

[3]Ruthven, Alexander G., Science, N. S., XXXIII, pp. 208-209. Wood, N. A., Wilson Bulletin, XXIII, pp. 78-112. Wood, N. A., Thirteenth Ann. Rept., Mich. Acad. Sci., pp. 131-134. Dodge, C. K., ibid., pp. 173-190. Andrews, A. W., ibid., pp. 168-170.

some of the snakes may have been carried over while hibernating in logs. There is little possibility that any specimens of these groups were ever accidentally introduced by man. The frogs, the water snakes, the rattlesnakes and the turtle are all more or less aquatic forms and probably swam across. It must be admitted however that these are little more than conjectures, as no data on the subject are at hand.

Without doubt the small number of species may be accounted for by the distance of the islands from shore and the length of time which has elapsed since they became inhabitable. The number of individuals is also very small and this may be explained by the limited areas in the different habitats, which leads to a greater persecution by enemies and a more limited food supply. Thus the only species at all common are the newt, which feeds on insects in the water, and the water snake, which can find food in the water all about the island. The other species are dry land or marsh forms that on the islands are restricted to small areas which can only harbor a small amount of food and which are thoroughly worked over by the flesh-eating birds.

LIST OF SPECIES.

1. **Necturus maculosus** Raf. Mud Puppy.—Altho no specimens were taken, Captain MacDonald reported the species as common in Saginaw Bay.

2. **Ambystoma jeffersonianum** (Green). Blue-spotted Salamander.—One specimen of this salamander was taken by Mr. Wood in 1910 and six in 1911. They were found in the debris under decaying boards at the base of Snake Point.

3. **Diemictylus viridescens** Raf. Green Newt.—This salamander was fairly common on the island. Ten in the terrestrial stage were taken in 1910 and seventeen in 1911. In 1911, Dr. Ruthven found them common in a pile of decaying boards back of the light-house. On their visit to the island, the writers collected one which was afterwards lost, under a board at the base of Snake Point.

4. **Bufo americanus** LeConte. American Toad.—A single specimen was taken on Charity Island, July 15, 1911. This toad, according to Captain MacDonald, had lived under the boat house for several years and was the only one he had ever seen on the island.

5. **Rana pipiens** Schreber. Leopard Frog.—Fourteen specimens of the leopard frog were taken, one in 1910 and the others in 1911. The writers found several in August, in the high grass along the south shore of the lake.

6. **Rana clamitans** Latreille. Green Frog.—Two specimens of this species were taken in 1910 and three in 1911. They were found under stones on the beach.

7. **Thamnophis sirtalis** (Linn.). Garter Snake.—Three garter snakes were collected on the island by Mr. Wood. These were the only ones seen but Captain MacDonald reported it as rather common at times.

8. **Natrix sipedon** (Linn.). Water Snake.—Water snakes are always abundant on the island. They are usually found under boards and rocks on the beach. Thirteen specimens were collected.

9. **Elaphe vulpinus** (B. & G.). Fox Snake.—Two specimens of this species were killed by Captain MacDonald, about 1896. This is the only record for the island.

10. **Liopeltis vernalis** (DeKay). Green Snake.—According to Captain

MacDonald this species was formerly rather common on the island, but it was not observed by the museum collectors.

11. **Lampropeltis doliatus triangulus** (Boie). Milk Snake.—Two specimens of this species were taken, the first in 1910. The other was found under a stone on Light-House Point in 1911.

12. **Sistrurus catenatus** (Raf.). Rattle Snake.—Rattle snakes are rarely seen on the Charities. One was taken by N. A. Wood, Sept 16, 1910, another was killed July 18, 1910, by W. W. Newcomb, and one was seen by A. W. Andrews in 1910.

13. **Heterodon platyrhinus** Latreille. Hog-nosed Snake.—Two specimens of this species have been seen on the island by Captain MacDonald.

14. **Chelydra serpentina** (Linn.). Snapping Turtle.—A single turtle was taken from the island pond, Sept. 13, 1910.

NOTES ON MICHIGAN BIRDS.[1]

BY N. A. WOOD.

There are a number of species in the ornis of Michigan which are so rare or seldom observed, at least in certain parts of the State, that all of the records obtained should be published. These rare birds belong to no one class, being occasional visitants, stragglers, forms that are nearing extinction, and forms that for one reason or another have never become common. It is the purpose of this paper to note the records for these species that have been received at the University of Michigan Museum in 1911 and 1912.

Gannet (Sula bassana).

The first Michigan record for this bird was obtained last year, when an immature specimen shot at Walker Lake, Livingston County, on October 19, 1911,[2] was sent to the museum. This species is a very rare straggler from the Atlantic coast, where it is known to breed on some islands in the Gulf of St. Lawrence.

Evening Grosbeak (Hesperiphona vespertina vespertina).

A flock of about twenty evening grosbeaks was seen from January 19 to February 19, 1911, at Ann Arbor. It seemed to have its headquarters about a box elder tree on Thompson Street. This bird is only very rarely seen in this vicinity. Six were seen on November 25, 1906, and it was rather common during the winter of 1889-90.

Duck Hawk (Falco peregrinus anatum).

Another unusual bird in this part of the State is the duck hawk, a specimen of which was seen at a small lake near Ann Arbor, by Mr. E. Lohr, on April 15, 1911. This is a true falcon and lives on ducks and smaller game birds which it pursues and captures on the wing. It mostly follows the spring and fall migrations along the shores of the Great Lakes, but is occasionally seen inland. The writer saw one at a small lake in Lodi Township, in August, 1880, chasing a flock of killdeer. Another was shot at Silver Lake, Freedom Township, March 10, 1884, and an adult male in the museum collection was taken at Ann Arbor in 1892.

Sycamore Warbler (Dendroica dominica albilora).

On April 22, 1911, one specimen of this species was taken on the north bank of the Huron River, between Ann Arbor and Ypsilanti, by F. Novy. This rare species probably reaches its northern limit in Michigan at this place for it has not been found farther north. The name

[1]From the University of Michigan Museum of Natural History.
[2]Recorded in the Wilson Bulletin, Vol. XXIV, pp. 43-44.

was given because of the habit of feeding and nesting in the sycamore trees that are generally found along the banks of the more southern streams, and it is found in no other habitat in this region. The first birds observed in this vicinity were taken below Ypsilanti, on May 17, 1893, by Dr. J. B. Van Fossen. It was not noted again until 1906, when it was first seen by A. D. Tinker, April 22, and later, April 25, by the writer, in a grove of sycamores below Geddes. It was seen again at this place on April 26, 1908, and as late as June 21 by Tinker, and that year the species no doubt nested in the grove.

Upland Plover (Bartramia longicauda).

The upland plover was seen near Manchester, Washtenaw County, on April 19, 1911. This is the only record for the year in this region, where the bird used to be a not uncommon breeder twenty-five years ago. The species is almost extinct in this vicinity.

Sandhill Crane (Grus mexicana).

A flock of about twenty sandhill cranes was seen near Unadilla, Livingston County, March 24, 1911. This region is full of sand hills and tamarack marshes, and the species has bred there since our earliest knowledge of the region. Previous records for the locality are a nest with two eggs found in May, 1896, an adult male in the museum collection taken on May 25, 1897, a female taken on October 25, 1900, and an immature bird secured in October, 1910.

Pigeon Hawk (Falco columbarius columbarius).

This species, like the duck hawk, is very rare in this vicinity, seeming to prefer the shores of the Great Lakes in migration. A single bird was observed near Ann Arbor, May 9, 1911. A fine male in the museum collection of mounted birds was taken at Ann Arbor on October 19, 1890, and an adult female on November 5, 1900, at Steere's swamp.

Kirtland Warbler (Dendroica kirtlandi).

Another Kirtland warbler was seen at Ann Arbor, on May 10, 1911. This is the tenth record for this locality, and they are all for May (from the 6th to the 16th).

Yellow-breasted Chat (Icteria virens virens).

A pair of yellow breasted chats was found in the willow thicket at Steere's swamp on May 13, 1911. In this region the species has only been found at this particular place, and here only a few times—May 20, 1894, May 16, 1906, May 8 and July 20, 1909, and May 13, 1911.

Short-billed Marsh Wren (Cistothorus stellaris).

A short-billed marsh wren was seen on September 10, 1911, at a marshy pond near Ann Arbor. The species seems to be a very local and rare bird in Michigan, and this is the only record for this vicinity since June 20, 1870, when J. W. Detwiller found a small colony nesting near

Honey Creek two miles west of town. F. Gaige found it nesting near Manchester (twenty miles southwest of Ann Arbor) on June 22, 1907, and on June 13, 1908, found others at the same place with nests and young.

Shoveler (Spatula clypeata).

One shoveler duck was seen at Portage Lake, Washtenaw County, on September 20, 1911. This species also seems to be a very rare migrant in Michigan. The very few records that we have for this vicinity are as follows: April 20, 1899, October 1, 1907, April 12, 1908 (the writer saw three at Four Mile Lake), March 27, 1909 (three were seen at the "overflow").

Baldpate (Mareca americana).

The baldpate is another scarce migrant for which we have few Washtenaw County records. A flock of twenty was seen on the Huron River on March 25, 1911, and one was shot, November 4, 1911, by Mr. W. F. Hale at Four Mile Lake. Other records are September 24, 1911 (the writer saw a small flock at Four Mile Lake), March 28, 1910. April 17, 1909 (two were shot at a small lake near Ann Arbor), and one was shot at Orchard Lake by R. D. T. Hollister, April 16, 1904.

Double-crested Cormorant (Phalacorax auritus auritus).

The double-crested cormorant is a scarce migrant in this vicinity although rather common along the Great Lakes. Two immature birds were taken near Jackson on October 20, 1911, and sent to the museum. Others mounted by the writer were taken at Saline, November 15, 1897, and at Whitmore Lake, November 25, 1900. The last two are the only previous Washtenaw County records known to the writer. The species is not mentioned in Covert's local list published in 1880.

Snowy Owl (Nyctea nyctea).

A large snowy owl with a broken wing was found, on January 18, 1912, in Lodi Township, five miles southwest of Ann Arbor. It was an adult male and very white. This species is a very scarce and irregular winter visitant in this vicinity and the records are few.

Lapland Longspur (Calcarius lapponicus lapponicus).

The Lapland longspur is a winter visitant in Michigan that is not infrequently seen along the coasts but which is quite rare in the interior of the state. On March 9, 1912, Frank Novy saw a number near Geddes, Washtenaw County. It has been recorded from this county but twice before and from the vicinity of Ann Arbor but once. A pair in the museum was taken near the city on February 10, 1885, by A. B. Covert, and the writer saw one in Lodi Township, February 10, 1885.

Old Squaw (Herelda hyemalis).

On March 9 of this year a fine adult male of this species was taken by Edward Gibson in a small area of open water in the Huron River, between Geddes and Superior, Washtenaw County. No others were seen by him but a few others were reported by local duck hunters. The continued severe cold weather and the frozen condition of the Great Lakes no doubt accounts for the presence of this winter duck in this vicinity. The species is mostly maratime, altho in the winter it is also found on the Great Lakes. It is an expert diver and hundreds are taken in deep water gill nets on the lakes. The first record for this county known to the writer was secured on December 10, 1901, when several were taken in Portage Lake outlet and mounted at Ann Arbor.

NOTES ON MICHIGAN MAMMALS.[1]

BY N. A WOOD.

A number of Michigan mammal records that deserve notice have been received at the University of Michigan Museum during the past year.

Badger, Taxidea taxis (Schreber).

A large badger was caught near Base Lake, Washtenaw County, on February 15, 1911, by John Hayes; another, that subsequently escaped, was taken about a mile north of Ann Arbor on December 3, 1911, by Eugene Haas, and a third was secured at Chelsea on January 20, 1912, by Mr. T. Alber.

Seton (Life Histories of North American Mammals, p. 997) gives only one Michigan record for this species—our tentative Porcupine Mountain record—and his map of distribution does not include the whole state but extends through central Wisconsin south around the end of Lake Michigan and across the southern end of the lower peninsula. The species is not of rare occurrence throughout the entire state but is seldom seen on account of its nocturnal and fossorial habits. It is equally at home in the dry oak openings of the south and on the sandy plains of the north. The writer has nearly sixty actual records for the state and twelve for Washtenaw County alone.

Opossum, Didelphis virginiana Kerr.

An immature female opossum was captured by Eugene Haas, January 8, 1912, about a mile north of Ann Arbor. It was trapped under an old deserted house, on a very cold night, and the animal was dead when removed from the trap the next day. On the night of February 5, 1912, another opossum was taken at the same deserted house by Mr. Haas. These animals no doubt lived in a burrow (probably made by a woodchuck) in the old cellar. These records are the eleventh and twelfth known to the writer from this county alone, and it is no doubt just as common throughout the southern part of the lower peninsula. We have records as far north as Ottawa, Genesee, and southern Isabella Counties.

Owing to its omnivorous feeding habits, prolificness, and nocturnal habits, this species holds its own and even increases with civilization, and is restricted in its northern distribution mostly by temperature. However, it is also apparently able to withstand quite low temperatures. The above specimens were both caught on very severe nights, the thermometer registering 6° F. on January 18 and—12° on February 5. One would expect that the species would not leave a warm home or nest on such nights. The raccoon certainly does not venture out in winter

[1]From the University of Michigan Museum of Natural History.

except when it is quite warm and it is much more hardy than the opossum.

Raccoon, Procyon lotor (Linnaeus).

A pure albino raccoon was taken in Lodi Township, about eight miles southwest of Ann Arbor, on December 24, 1911, by J. Alber. It was very fat, although no doubt less than a year old, and weighed twelve pounds. This is the sixth albino of this species known to the writer from this county during the last forty years.

Meadow Mouse, Microtus pennsylvanicus (Ord.)

A nearly pure albino of this species, an immature male, was taken near Salem, Washtenaw County, by E. D. Walker, on December 7, 1911, and presented to the Museum. While this species is very common in this region, often doing much damage to small fruit trees as well as grass and grain crops, albinos are very rare, and the only previous record known to the writer was a perfect specimen caught by him, in July, 1875, in a low wet meadow in Lodi Township, Washtenaw County.

DIRECTIONS FOR COLLECTING AND PRESERVING SPECIMENS OF REPTILES AND AMPHIBIANS FOR MUSEUM PURPOSES.[1]

BY ALEXANDER G. RUTHVEN.

Few groups will better repay the collector than the reptiles and amphibians, for more specimens of most of the species are needed, and there are few regions from which collections are not greatly to be desired. For these reasons persons interested in natural history, as well as collectors generally, should make an effort to preserve at least such material as comes to hand. The writer is convinced that much of the neglect of these groups by collectors is due to a lack of knowledge of how to conveniently preserve specimens, and having often been asked for information on this point has attempted in this paper to formulate simple instructions that may be carried out without an elaborate equipment by persons who wish to obtain specimens for the museum.

EQUIPMENT.

The apparatus needed for the collection and field study of reptiles and amphibians is not extensive. The list given below contains the tools and materials that the experience of the writer has found most useful. Of these things, the collecting implements are not, of course, absolutely necessary if one intends to preserve only the specimens that are easily caught in the hands, but the other tools and materials are quite essential to the proper preservation of specimens and should always be carried.

For Collecting Specimens.

Gun and ammunition.
Turtle net.
Dip net.
Cotton cloth bags of various sizes.
Game bag or creel.
Placental forceps.
Fish-hooks.

For Preserving Specimens.

Scalpel.
Small scissors.
Bone saw.
Rubber gloves.
Hypodermic and universal syringes and needles.
Formalin (Sherings).
Alcohol (96%).
Glycerine.
Measuring cup.
Arsenic, salt, powdered alum, tow or cotton batting, large skinning knife, strong linen thread, surgeon's needles, galvanized iron wires (No. 18), if dry skins are to be put up.
Bottles, vials and corks.
Pans, preferably of granite ware.

[1]From the University of Michigan Museum of Natural History.

For Recording Data and for Field Studies.

Note books and pencils.	Field glasses.
Labels.	Camera and supplies.
Code of colors.	Tape line.

The most satisfactory gun to use for extensive collecting is a 28 or 44 gauge shot gun. For most specimens empty shells should be purchased, and loaded with small charges of powder and dust shot (No. 14) as needed. The writer has discarded brass shells, preferring to buy primed paper shells and throw away the exploded ones. The exact load will depend upon the size of the animal, distance, etc., and is easily learned by experience. The large lizards (e. g., iguanas) and turtles may be shot with full charges (1¾ dr. of powder and ⅝ oz. of No. 6 or 8 shot). A very effective gun for small specimens is a .22 caliber target pistol or rifle, bored smooth and shooting the .22 caliber shot shell. A gun will be found necessary if a complete series of the forms in a region is desired, or in the obtaining of series of specimens of some species in a short time.

There is no way of securing turtles and crocodilians so conveniently as with a trap net. The funnel hoop nets, without wings, are very good for this purpose and may be had in various sizes. A double-throated net 2 feet in height and with a 1¼ inch mesh is a good size for general collecting. For small aquatic animals linen minnow dip nets, 20 inches deep, with a ¾-inch mesh at the top and a ⅜-inch mesh at the bottom, attached to 6 foot handles are almost indispensable.

One of the most convenient articles that can be added to the collector's outfit is a series of cotton cloth bags of various sizes. These are for the reception of specimens in the field. As a rule, a bag 12 inches deep and 7 inches wide will be most often needed but a few larger sizes should be added, particularly if collecting is done in a country where species of large size abound. Tie strings may be sewed to the bags or draw strings may be provided, but the writer has found that, for several reasons, it is better to carry some short strings for the purpose.

Long forceps may be used for a variety of purposes. They are often necessary to pick up venomous reptiles or wounded animals that can bite appreciably hard, or to pull specimens out of holes, from under thorny bushes, etc. They are also convenient for lifting specimens out of the preservative. For most purposes, the heavy forceps (Fig. 1b) 300 mm. long that are designed for removing specimens from deep jars are the best, but where large specimens are handled, heavy placental forceps (Fig. 1a) are preferable as they cannot be twisted.

Strong fish-hooks may be utilized in several ways. Straightened and fastened to a stick they will serve as spears for frogs or specimens that have taken refuge in crevices where they cannot be reached with the forceps. They are also very convenient if specimens are to be skinned, for they may be hung by a strong cord and used to suspend the body at a convenient height while the skin is being removed.

Field glasses and a camera are valuable additions to the collector's outfit, but not absolutely essential to the work. By means of the former the habits of individuals may be studied more easily, and photographs of the habitats of the different species are very desirable.

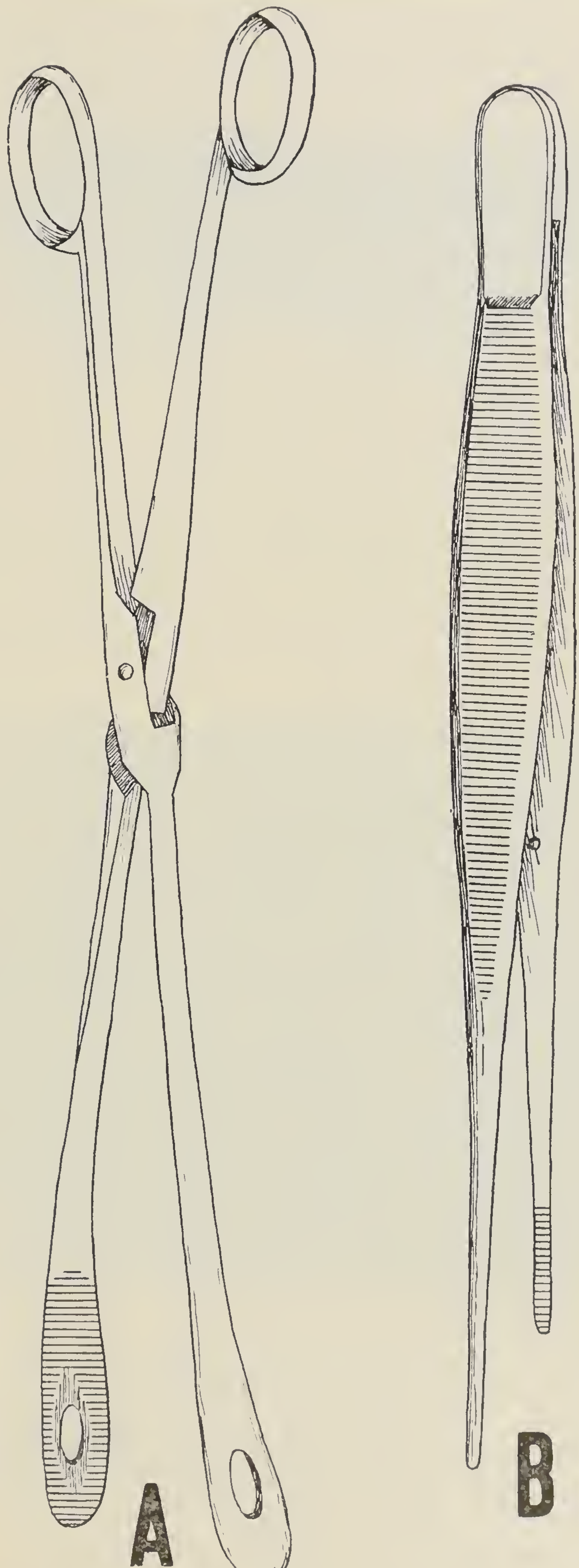


Fig. 1.—Large forceps that are convenient in the collecting of reptiles and amphibians.

The matter of labels is usually given the least attention when it should have the most (see p. 177). The writer believes that a metal label is by far the best for the field. Every expedition sent out from the University of Michigan Museum is supplied with a series of small pure tin tags, stamped with consecutive numbers from 1 up, provided with strings, and arranged in order on wire loops, each holding 100 labels. Metal tags are not always easily obtained by private collectors, and in this case small paper tags will serve the purpose. These should be about an inch square, of stiff white paper, provided with strings, and should bear a serial number written with a medium soft pencil (e. g. Kohinoor H. B.) or India ink.

The notebook is as important as the labels. When only a small amount of collecting is to be done one book will suffice. A convenient arrangement is to use the front part of the book as a field catalog, furnishing it with serial numbers corresponding to the labels and with enough space between the numbers for full notes, and to reserve the back part for general notes on habitats, etc. When extensive collecting is to be done it is well to have two note-books, one to leave at home and one to carry into the field, the former having the numbers and to be used as a catalog, the latter to be used as a daily journal of observations. A leather bound book such as is used by surveyors is preferable, as it is less easily damaged by water. A convenient ruling for the field catalog is shown in Fig 2.

A code of colors may be dispensed with if little time is to be devoted to the work, but persons desirous of getting the most valuable results should have one. The writer has found the "Code des Coleurs," by Klincksieck and Valette,* a very good color key, with the additional advantages of simplicity and reasonable price.

Hypodermic syringes are not strictly necessary, as the specimens may be opened with a sharp knife or scissors, but the specimens look so much better if injected that a syringe will well repay the cost. Only the all metal syringes (Fig. 3c) should be purchased. The most practical size is the hypodermic syringe of 12 cc. capacity, and this should be provided with some small needles and one or two large ones (those used for spinal injections). If many large specimens are to be prepared, a universal syringe of 4 ounce capacity will be found very satisfactory. This should be provided with some long hypodermic needles (100 mm. long), and the writer has found that a long canula (160 mm. long) with the end filed off diagonally to form a sharp point makes an excellent needle for the injection of large, tough-skinned specimens.

A pair of rubber gloves should be added to the outfit if one expects to preserve a considerable number of specimens, as the formalin solution is hard on the hands.

The scalpel and scissors are for skinning or opening specimens, the bone saw to remove the shells of turtles (Figs. 3a, b, d).

If nothing else is to be had, ordinary commercial formalin will do for the preservation of specimens, but the results are so far superior when Shering's formalin is used that a special effort ought to be made to have it. The stock is to be considered 100% when diluting (with water) to the strength used as preserving fluid.

*This book may be purchased from Paul Klincksieck, 3, rue Corneille, Paris.

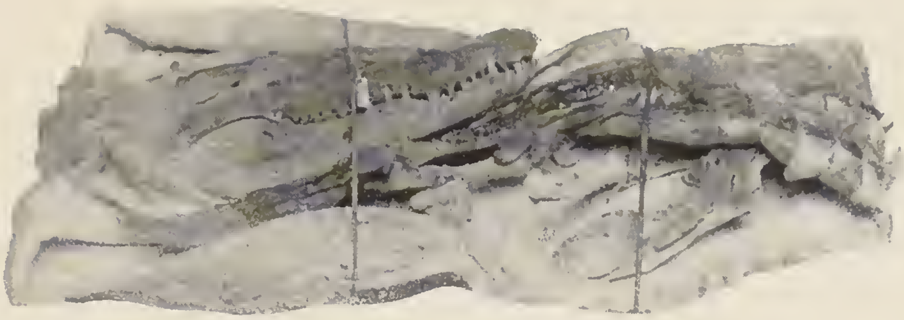
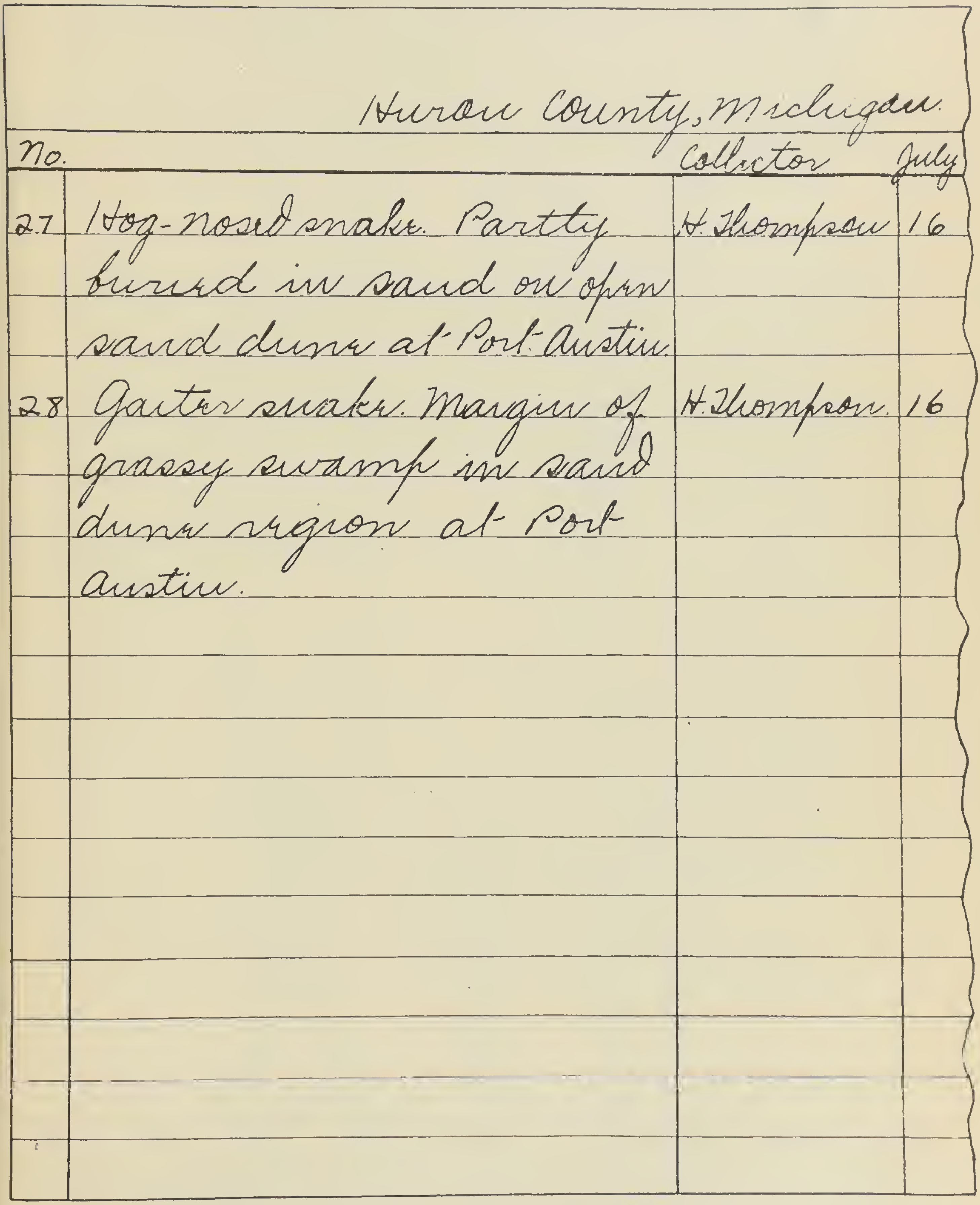


FIG. 4.—Crocodile skin ready for shipment.

FIG. 5.—Ventral surface of turtle, showing position of opening cut.



Huron County, Michigan.

No.		Collector	July
27	Hog-nosed snake. Partly buried in sand on open sand dune at Port Austin.	H. Thompson	16
28	Garter snake. Margin of grassy swamp in sand dune region at Port Austin.	H. Thompson.	16

Fig. 2.—Reproduction of a page from a collector's field book

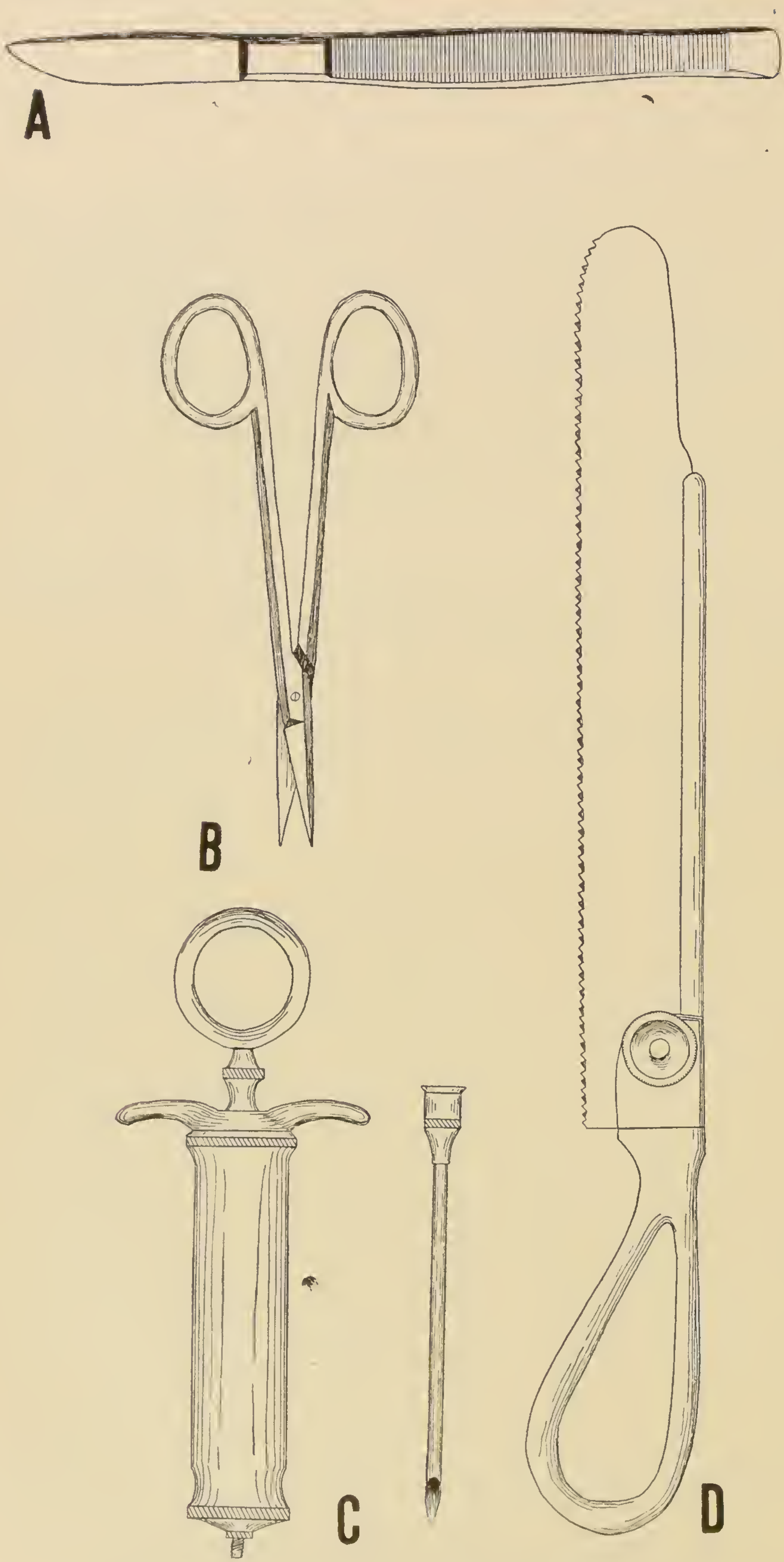


Fig. 3.—Tools used in the preparation of reptiles and amphibians for preservation.

The alcohol used should be ethyl alcohol. The stock strength of 96% should be purchased, and dilutions made from this.

The arsenic, tow or cotton batting, salt, alum, linen thread, skinning knife and surgeon's needles are used in the preparation of dry skins and may be omitted from the outfit when only specimens that may be preserved in liquid are to be collected.

A number of bottles and vials of various sizes and fitted with corks should be available, for delicate specimens should be placed in these for permanent storage or shipment.

GENERAL INSTRUCTIONS.

The motto of the collector should be "a poor specimen is better than none," and thus he should save the first specimen of each kind that comes to hand, but this should not be extended to mean that poor specimens are good enough. A well prepared specimen is immeasurably better than a poorly prepared one, and so little effort is needed to properly preserve most reptiles and amphibians that there is little excuse for spoiling specimens by improper preservation.

The first prerequisite of a good specimen is that it must be properly labeled. It is not too much to say that the value of a specimen is to a large extent in direct proportion to the amount of accurate data accompanying it. Every specimen, therefore, should be numbered and full data in regard to it entered in the notebook.

It is also desirable that series of specimens be secured. Owing to the variability of the different forms, a series gives a better knowledge of the characters of a species in a particular region than does a single specimen. An effort should be made to obtain considerable numbers of specimens of each kind, and the number of each form obtained may conveniently be in proportion to the abundance. Some collectors give the rarer forms most attention, but the writer believes that the most valuable collection may be made by taking as many of the rare forms as possible but at the same time getting large series of those most abundant. The latter can usually be obtained without interfering with the general work and the large series will furnish most valuable data on variation, etc. On the other hand, it should be borne in mind that the smaller forms are generally the least known and hence more desirable than the large showy ones, so that, while the latter should not be neglected, they should not be allowed to monopolize the collecting.

Another desirable attribute of a collection is exhaustiveness. Even a few specimens from any one region are of value, but it is much preferable to try to obtain specimens of all the species in a particular region.

COLLECTING.

Little needs to be said on the subject of collecting, for the method will vary with the facilities at hand and the position of the specimen. Most of the specimens may be grasped in the hand, but the larger and the more agile ones will usually have to be shot, and it will also be found that much time will be saved by using a gun if series are wanted.

As stated above, crocodilians and aquatic turtles can be secured in no way so easily as with a trap net. These animals sink to the bottom

when shot, and are then obtained with difficulty unless the water is quite shallow. The largest crocodilians must be shot with a rifle, but such specimens will not usually repay the trouble of collecting and preserving if young individuals are to be had. The dip net is to be used for small aquatic forms such as small turtles and aquatic amphibians. If it is desired to capture specimens of snakes and lizards alive those not easily caught in the hands may be noosed. Fine annealed iron wire is said to be excellent for this purpose. Stejneger* has the following to say on the subject: "Various sizes [of wire], from Nos. 22 to 34, may be found useful; the larger sizes might probably be quite as serviceable if of copper. For larger snakes a noose of waxed twine will be found to work well in many cases, and is to be recommended to persons who are too nervous to grab a live snake with an unprotected hand.

"The noose should be fastened to the end of a long stick, or a light switch, as the case may require, and if a few leaves are left at the end so much the better, as they will attract the reptile's attention from the noose. Slip the noose gently over its head and a sharp jerk towards the tail will usually put the prize in your possession."

Whether the specimens are obtained alive or dead they should be at once slipped into cloth bags, and if a considerable collection is made on one trip a note giving the place of capture should be inserted or tied to each bag. If the specimen is an amphibian the bag should be wet in water. When in the field write a description, and if convenient make photographs of the habitats and record any observations on habits.

CARE OF SPECIMENS.

Preservation of the Entire Animal.

By far the best method of preserving reptiles and amphibians is in formalin. All of the amphibians and all but the very large reptiles should be put up in his way, and in the case of the latter it is quite permissible to preserve the young ones in formalin and ignore the large individuals.

Adult Stages: Upon returning to camp the live specimens should be drowned by immersing the bags in water. The dead specimens should be removed from the bags, the blood washed off and the limbs straightened out if they have been twisted into unsightly positions. They should then be thoroughly injected with a 4% solution of formalin (considering the stock as 100%). By thorough injection is meant that the preserving fluid should be injected into the body cavity until the body is plump, but not until the skin is abnormally distended as this is unnecessary and produces an unsightly specimen. One injection, on the ventral surface, is sufficient for all but the very large amphibians, turtles, large lizards and crocodilians, and snakes. Very large amphibians should have the thighs injected; large lizards and crocodilians of the same size should also have the base of the tail and fleshy parts of the limbs injected; and in the case of snakes it will be necessary to inject the preservative in several places along the ventral surface and in large specimens into the base of the tail. Care should be taken to inject the fluid slowly and uniformly so as not to cause distortions. Turtles are

*Bull. 39, U. S. National Museum, Pt. E, p. 9.

injected in the body cavity (inserting the needle behind the fore legs and in front of the hind legs), in the neck, and in the fleshy parts of the limbs and tail. If a syringe is not used, make slits through the body wall in the places where the injections would be made. Open the mouth of turtles and amphibians, securing it in that position by inserting a piece of wood or a cork in the case of turtles and a plug of cotton in the case of amphibians.

Having prepared the specimens to be preserved entire in formalin, before placing in the liquid tie on the labels and enter the data in the notebook opposite the corresponding numbers. The date and place of capture, collector's name, nature of habitat, notes on habits, and, preferably, general color notes (i.e., exact shades of color but not pattern) should be recorded, and any other information obtained. (See Fig. 2.)

Stejneger* has given a good account of how the label should be attached. "In tying the label on be careful not to fasten it tighter than necessary to prevent the label from slipping off. Never tie a label round the neck of a specimen; in lizards and salamanders fasten it round the body just behind the fore legs; in frogs and toads in front of the hind legs; in snakes round the body at about the anterior third; finally, in turtles, tie the string to one of the legs, and only in this case is it necessary and permissable to draw it very tight."

If the specimens are to be sent to the museum, they may, when thoroughly hardened, be removed from the pans and packed rather closely in glass bottles or jars, crocks, or wooden containers (metal containers are seldom satisfactory) and covered with 4% formalin. If it is desired to preserve them permanently transfer the specimens, when thoroughly hardened, from the formalin to alcohol. For amphibians the alcohol should be about 55%, for reptiles 75%.

Eggs and Larval Stages: Eggs and the larval stages of the amphibians may be dropped directly into 2% formalin, and if later transferred to 4% formalin they may be left there permanently. Boulenger† also gives the following method of preserving tadpoles: "Tadpoles should be preserved in alcohol. Chromic acid is not to be recommended, as rendering the specimens too brittle for ordinary study. To ensure the good condition of specimens preserved in spirit, it is necessary to treat them with a little care; tadpoles thrown into the ordinary collecting-bottle promiscuously with other specimens are never in a satisfactory condition for display in a collection and for future study. The best plan is to provide one's self, when going out collecting, with small test-tubes half-full of weak spirit; the tadpoles, when taken out of the fishing-net, should be dipped head foremost in the tube, which may be filled with as many specimens as it will hold. On reaching home, say two or three hours later, the liquor should be at once changed to strong spirit (40%), which will again require changing the next day, and so on until it ceases to be strongly colored. By this method, of killing in weak spirit and then seizing by strong spirit, the tadpole preserves its natural shape in a remarkably perfect manner, and the delicate caudal crests do not shrivel." These specimens are generally so delicate that only a paper label may be placed in the bottle, but if metal numbers are being used these may be tied to the neck of the bottle. Such specimens are to

Loc. cit., p. 10.
†Proc. Zool. Soc. London, 1891, 599.

be preserved in lots when they are so taken, and the same care should be used in recording the data.

Preservation of Skins.

As a rule it will not pay the general collector to attempt the preservation of specimens too large to be conveniently preserved entire in formalin. Small specimens of the larger forms may usually be had, and these will suffice. However, if one is willing to take the trouble, a few adult specimens of the large lizards, crocodilians, turtles and snakes will increase the value of the collection, and these may be preserved as skins. In the case of lizards, make a cut along the median ventral line from between the fore legs to the forward end of the abdomen. Skin the neck and anterior part of the body through this cut, disarticulating the head and the fore limbs at the shoulder. Then hang the animal by a fish-hook thrust through the skinned neck and carefully skin the body backward, turning the skin inside out in the process and disarticulating the hind limbs at the pelvis and the tail, leaving these members, like the fore limbs and head, with the skin. Turn the skin right side out again. Determine the sex on the body and record it in the notebook, and then, after removing the stomach and tying it to the skin, throw the body away. Label the skin and preserve it in formalin.

Large snakes to be skinned are treated as follows: First measure the total length and length of tail. Then slit the ventral surface along the median line from the neck to within one or two inches of the anal opening and skin the body through this slit, disjointing the head and tail and leaving these members with the skin. Label the skin, tie the stomach to it and preserve in formalin. If there are any embryos, remove the oviducts and preserve under the same number as the skin.

Hornaday's* method of preserving large crocodilians has proved very satisfactory. "For the sake of science in general, and the taxidermist in particular, measure the crocodile carefully and record the dimensions. Divide the skin along the under side, following the median line from the throat to the tip of the tail, in one long, straight cut. Beginning at the end of each middle toe, divide the skin along the bottom of the foot and the under side of the leg, up to the point where the leg joins the body, but no farther. Then begin at the edges of the first cut, and skin as far down the sides of the body as possible. When the legs are reached, detach them from the body at hip and shoulder without cutting the skin, and continue on round the body until the backbone is reached and the skin entirely detached. Sever the head from the neck at the first cervical vertebra without cutting the skin. Skin out the tongue and remove the flesh from the palatal apertures and various cavities of the head. Skin each leg by turning the skin wrong side out until the toes are reached. Leave all the bones of each leg attached to each other and to the skin itself at the toes, but cut away the flesh carefully, the same as in skeletonizing. Remove from the skin as much as possible of the flesh which will be found adhering to it. When the skin is thoroughly clean, immerse it in a strong bath of salt and water, and

*Taxidermy and Zoological Collecting, pp. 67-68, New York, 1894.

allow it to remain twenty-four to thirty hours. Then take it out, rub the inside and the leg bones thoroughly with strong arsenical soap [or rub dry with a cloth and apply powdered arsenic], after which apply [salt and] powdered alum liberally over the inner surface, so that not a single spot is missed, then hang the skin up by the head (no danger of stretching in this case), and allow it to dry in the wind and the shade. When almost hard and stiff, take it down and fold it as carefully as if it were a Sunday coat, so that it can be packed in a box of ordinary dimensions." (Fig. 4.) The specimen should be labeled, the sex recorded and the stomach preserved in formalin under the same number as the skin.

The larger turtles may also be skinned and in the following way. With a small bone saw, saw through the bridge which unites the shell of the back (carapace) with that of the under surface (plastron); then divide the skin around the plastron, as shown by the dotted line in the figure (5), leaving enough attached to the plastron to permit the cut to be sewed up after the body has been removed. Then, with a knife, detach the plastron from the flesh of the body, leaving the skin attached to the front of the plastron. Turn the plastron up and over the head to completely expose the interior, and remove the flesh and viscera. Unless the skeleton is to be preserved, the neck, shoulder girdle and pelvis may be cut out with the flesh and thrown away, the head being disjointed at the first vertebra, and the limbs at the girdles. The animal's legs and tail are skinned precisely as those of a small mammal, each of these members being detached from the body and pulled inward, thus turning the skin wrong side out; the bones of the legs are left attached at the toes, the tail vertebrae are removed. In the case of a sea-turtle, which has the front limbs developed as broad, flat flippers, the opening cut must extend on up the leg, quite out to the extremity of the flipper, but in the case of other species the feet may be skinned from the inside. Having removed all flesh from the entire subject (including the eyes), wash it clean, and if it is not to be preserved in formalin apply a liberal amount of dry arsenic to the inside surface, also putting some on the outside. By wrapping a galvanized iron wire with tow or cotton held in place by cotton cord, make a neck and insert one end into the posterior skull opening and draw into place by turning the neck skin right side out. Wires should also be placed along the leg bones and wrapped with them with tow or cotton. If the proper amount has not been wrapped on the wires at all points, stuff some cotton or tow into the hollows with the long forceps. Then fasten the free ends of the wires into the vertebrae, pack the interior of the shell with tow, place the plastron in position and sew up the opening cut with strong linen thread. If the climate is hot and humid, soak the head in 75% alcohol for a few hours after the skin has been made up. Label the skin, determine and record the sex and save the stomachs as in the case of crocodilians. When several specimens of one species have been preserved in formalin or as skins, others may be preserved as shells. In this case remove the plastron entirely by the opening cut, then remove all of the flesh and skin, wash the shells thoroughly, tie the plastron and carapace together and hang in the shade to dry.

Preservation of Skeletons.

If the collector is attempting to make an exhaustive collection of the reptiles and amphibians of a region, at least one or two specimens of each kind should be put up for skeletons. It is necessary, above all, that the species of each skeleton be known, and, as this is often unknown to the collector, the safest procedure is to preserve enough of the body so that the species can be identified. The most satisfactory way to do this is to remove the internal abdominal organs (except in the small amphibians and smallest lizards, which only need to be slit open along the abdomen) and preserve the specimen in 75% alcohol. The larger amphibians, all but the smallest lizards, and small crocodilians may be disemboweled through a longitudinal median ventral slit in the abdomen, and the turtles by removing the plastron, and the largest species should also have the fleshy parts of the limbs, and in the case of lizards, crocodiles and turtles the tail, opened by several long deep slits which will permit the preservative to penetrate freely. Care must be taken that the sternum and abdominal bones when present are not injured by the opening cut. Snakes may be opened on the median ventral line from the throat to within an inch or two of the anus and all of the internal organs removed.

When the species is known, the skeletons of large lizards and turtles may be roughed out and dried and large crocodile skeletons must always be put up in this way. In the preparation of a skeleton of this kind the skin is first removed, then the internal organs are taken out, and finally as much of the flesh is removed as possible, and the rough skeleton folded up, tied firmly together and hung in the shade to dry. We have generally found it best to poison these dry skeletons, which may be done by soaking them for one or two hours in a solution made by dissolving powdered arsenic in hot water. The solution is to be used after it has become cold. Skeletons prepared in either of the above ways will keep indefinitely, and can be readily cleaned and mounted at any time.

As in the case of all other specimens a number (preferably of metal) should be attached to the skeleton, and the data recorded in the notebook.

SHIPPING.

To ship, remove the larger specimens preserved in formalin or alcohol from the pans or other containers, wrap in cheesecloth wet in the preservative, pack in tight tin cans and ship by express. The small specimens should not be packed with the large ones nor too many large ones packed in the same container, and lizards should be packed so that the tails will not be broken. Small delicate specimens should be shipped in bottles and immersed in formalin. The dry skins and skeletons should be packed carefully in dry cotton, tow or excelsior.

When facilities for preserving the specimens are not at hand they may be shipped alive, if they are not to be over a week on the road. Tie the snakes in roomy cotton bags into which a small square of bolting cloth has been sewed and place in a wooden box. No packing is necessary unless the box is much too large, in which case some excelsior may be thrown in with the bags. The amphibians may be placed in a tin box with wet moss, and it is necessary to have a number of holes punched

in the top to provide air. Turtles and crocodilians may be placed in wooden boxes with dry hay or excelsior.

GENERAL REMARKS.

It will be seen from the above directions that specimens of the groups in question are easily prepared, and that no particular skill or elaborate equipment is necessary. A good collection does, however, demand two things of the collector, viz., carefulness in preparing specimens and accuracy in recording data. The adage that anything worth doing is worth doing well applies here. A collection of reptiles and amphibians from any locality is decidedly worth the effort, and the value of the collection increases directly with the pains that is taken with it. Care should be taken to avoid mutilating the specimens, to get the body and limbs in sightly shape before preservation, and to see that preservation goes forward perfectly,—a little more arsenic where spots on drying skins are slow to harden or more formaldehyde injected in places where the specimens in liquid show a tendency to spoil will save many valuable specimens. Above all, accuracy must be observed in labeling and recording notes, for a specimen with full data is immeasurably more valuable than one with little or none.

23

THE BREEDING BIRDS OF THE CHARITY ISLANDS, WITH ADDITIONAL NOTES ON THE MIGRANTS.[1]

BY N. A. WOOD.

The ornis of the Charity Islands, Lake Huron, was investigated in 1910 by the Mershon Expedition from the University of Michigan Museum. The papers that have been published on the results of this investigation are listed below,[2] and it is sufficient to say here that the expedition was made possible by the generosity of Honorable W. B. Mershon, Saginaw, Michigan, the work was under the general direction of Dr. A. G. Ruthven, the Head Curator of the Museum, and the vertebrate collections were made by the writer.

As the result of the work in 1910, 162 species of birds were recorded from the islands, 35 of which were supposed to have bred there that year. But as the work was not begun until the nesting season had passed most of the data secured was on the fall birds. In order to make our knowledge of the birds of the island more complete, the Michigan Geological and Biological Survey decided to supplement the results of the Mershon Expedition by work on the birds during the breeding season in 1911. This work was also given to the writer, who spent four weeks on the islands, from July 4 to July 31. The present paper is the result of this work. It will be noted that to the 162 species listed in 1910, eight (white-winged scoter, whistling swan, green heron, red-backed sandpiper, chipping sparrow, tree swallow, bank swallow, Carolina wren) have been added, and breeding records for 37 species have been secured. Additional notes on the early fall migrants are also included.

The writer has again to acknowledge the assistance of the Charity Island Light-House Keeper, Captain Charles McDonald, and the Assistant Keeper, Mr. Joseph Singleton. Since the work of 1910, these men have made observations and collected material for the Museum, and during the work in 1911 they assisted in every way in the obtaining of results. Some of the photographs were made by Dr. Ruthven and some by Miss Crystal Thompson and Miss Helen Thompson, Assistants in the Museum. The map was prepared by Miss Helen Thompson.

A general description of the islands is given in the papers listed above. The group comprises two small islands and a rocky islet, and is situated near the mouth of Saginaw Bay (Fig. 1). Charity Island, containing 640 acres, is more or less thickly covered with the original forest, which consists of red oak, maple, and scattering Norway and white pine on the higher parts and of a fine stand of white birch on the low ground.

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[1]Published by permission of Alexander G. Ruthven, Chief Naturalist of the Michigan Geological and Biological Survey.

[2]The Mershon Expedition to the Charity Islands, Lake Huron, by Alexander G. Ruthven, Science, N. S., XXXIII, pp. 208-209.

Results of the Mershon Expedition to the Charity Islands, Lake Huron:
- Birds, by N. A. Wood. Wilson Bulletin, July, 1911, pp. 78-112.
- Plants, by C. K. Dodge. 13th Ann. Rept. Mich. Acad. Sci., 1911, pp. 173-190.
- Mammals, by N. A. Wood. 13th Ann. Rept. Mich. Acad. Sci., 1911, pp. 131-134.
- Preliminary Report on the Coleoptera, by A. W. Andrews. 13th Ann. Rept. Mich. Acad. Sci., 1911, pp. 168-170.

(Fig. 15.) At the south end of the island some of the ridges are largely without trees (Fig. 8). Most of our time was spent on this island, headquarters, as in 1910, being established at the light-house, which is located on the north shore (Fig. 2). The localities on this island referred to are as follows: Light-House Point—the northernmost point, on which the light-house is situated (Figs. 2-3). East Point—the most eastern point (Fig. 5). Rattlesnake Point— the point lying between Light-House Point and South Point on the west side of the island (Figs. 11, 13). Horseshoe Bay—the bay on the east side of the island. The pond (Figs. 9-10) on the west side.

Little Charity Island (Fig. 20) lies about three miles southwest of Charity and is much like it except that the forest, which never was as luxuriant as on Charity Island, has been largely cut off. There is an abundance of wild berry and other bushes, which create better conditions for the ground species, such as the sparrows, which bred there much more commonly than on Charity Island.

Gull Rock (Figs. 16-19) is only a sand and rock islet which has been left bare by the lowering of the lake level during the past thirty years. (In 1880 Captain McDonald sailed his boat over the present site of this island.) It is now almost completely covered with water at every hard storm especially in the spring, but during the summer about one-fourth of an acre is exposed. The vegetation consists principally of smartweed (*Polygonum hydropiper* L.) and a few scrubby willows.

GENERAL OBSERVATIONS.

Two general facts in regard to the breeding birds of the island are worthy of record. In the first place the number of species and individuals is small. At present only 37 species are known to have bred on the islands, and even the most common species were with few exceptions limited to three or four pairs. The paucity of species and individuals may be explained by the small number of habitats, the smallness of the area, which restricts the habitats, and the distance of the islands from the mainland. The principal land habitat (for breeding birds) is the forest on the ridges on Charity Island, but even here only three species (crow, red-eyed vireo and cedar bird) were at all common, and the crow was not confined to the habitat or the island. The next most extensive habitat is the interior of Little Charity Island, which has been mostly cleared and supports a relatively large number of song sparrows and field sparrows, and barn swallows about the buildings. The third most important bird habitat is undoubtedly Gull Rock, which is inhabited only by the common tern which breeds there by the hundreds, and the beaches on the other islands. The other habitats such as low thickets, quiet bays, ponds, etc., are very restricted and hence afford a limited food supply and support a meager ornis, many of the most common forms on the mainland not being found here.

The position of the islands in respect to the mainland also with little doubt serves to restrict the bird life, for it is apparent that the islands or the proper habitat when present may be missed by the bulk of the species on the spring migration. This is shown by the fact that the breeders vary from year to year. Only a few examples can be given owing to the short period covered by investigations, but these are with little doubt typical examples of what occurs annually in the population

of the islands. This year a pair of killdeer nested on the bare gravel near the light-house and only a few feet from the cement walk. Captain McDonald says it is the first time the species has bred here in the past thirty years. The wood duck, which formerly nested here, has been absent for several years, and the piping plover, which was a rare breeder as late as 1909, has not been observed since then. From these examples and the few pairs of breeding birds each season it will be seen that the list of breeding birds probably varies from year to year and to a much greater degree than in an area of the same size on the adjacent mainland.

LIST OF SPECIES.

1. **Larus argentatus.** Herring Gull.—This was one of the few species seen every day, and a flock of about two hundred, mostly adult birds, was seen on Gull Rock and on Little Charity Island (Figs. 16, 20). These birds visited daily the several fishnets and were always about when the latter were lifted, to feed on the fish. The light-house keepers thought they had been about Gull Island since the ice went out. The writer often saw flocks of forty or fifty about sundown, flying high and due north, and was told that the species breeds on islands about Thunder Bay, seventy five miles north of the Charities. It may be that some or all of this flock bred there and fed about Saginaw Bay. It is possible that all were males and had little interest in the nest and young, or they may have been unmated birds. Toward the latter part of the month the flock was increased by immature birds, probably the young of the year. It is possible that the species once nested about the islands of Saginaw Bay, but at the present time none are known to do so.

2. **Sterna hirundo.** Common Tern.—A large colony of this species nested on Gull Rock. Most of the eggs were laid in June, but on July 14 the writer found fresh eggs as well as young birds of all sizes, many of them in nearly full feather, although not able to fly. When alarmed dozens of young birds took to the water and swam off for some distance while others hid in the thick growth of smartweed (*Polygonum hydropiper* L.) that almost covered the islet (Fig. 16). The usual number of eggs seemed to be three, although some nests contained four, a very few five, and one had six. The space is very small for such a large colony and the nests were so crowded that many of them no doubt contained the eggs of two birds. A few dead young were seen, and one adult bird was found dead (Figs. 18-19). The writer estimated the number of adult birds in this colony at one thousand.

On July 28 the colony was again visited and the conditions were found to be much the same as on the previous visit, except that hundreds of newly fledged young were out on the bare rocks at the end of the ledge (Fig. 17). A few nests contained eggs (some probably unfertilized) and newly hatched young,while many young in all stages of growth were hiding among the rocks and in the thick growth of smartweed.

3. **Mergus americana.** Merganser.—This is a rather common breeder on the islands. Adult females with broods of young were found on our arrival at Charity Island, July 6, at which time all the young had evidently hatched. An adult bird and brood were seen at Gull Rock on July 10, and the young were still small and covered with down. A brood of eight was seen on the rocks at South Point (Fig. 14), Charity Island, on July 17, another of five young on the west side between Snake and South Points,

and a brood of seven at Snake Point (Fig. 13). No nests were found by the writer, but a great number of suitable cavities were seen in the old oak trees. Mr. Singleton has found nests of this species on the ground among the rocks on North and Stony Islands.

4. **Anas rubripes.** Black Duck.—The black duck was not seen in 1911, but a flock of nine was seen several times about Gull Rock in 1910. These were probably bred on one of the islands, as they were too young to fly when first seen.

5. **Dafila acuta.** Pintail.—This species was reported by the keepers as not uncommon about Charity Island in spring and fall, and during the spring of 1911 one was thought to have nested on Snake Point. Mr. Singleton looked in vain for the nest, but later some young ducks appeared about the island and were seen by the writer, on July 6, in the pond. This brood was seen about the beaches and when approached always swam off into the Bay. On July 29 two of these young birds (a male and female) were seen, and they could barely fly. The writer has been unable to find any breeding record for the state, but the A. O. U. Check-List records it as breeding as far south and east as northern Illinois.

6. **Oidemia deglandi.** White-winged Scoter.—On July 7, the writer found the dried remains of four scoters on the beaches (Fig. 6-7) of Charity Island. Captain McDonald stated that they are rather common on Saginaw Bay in the late fall, and on Nov. 11 an adult male collected by Mr. Singleton on Charity Island was received at the Museum. The fishermen call this the "big black duck" to distinguish it from the common black duck.

7. **Olor columbianus.** Whistling Swan.—On April 15 the keepers saw nine swans near East Point, where they fed and rested on the water all that day. They were the first ones ever noticed near the islands by the keepers.

8. **Botaurus lentiginosus.** Bittern.—Only one bittern was seen, a bird that flew over the Charity Island clearing on the morning of July 27. Later in the day it came again to the clearing and flew about overhead. The species probably did not breed on the islands either in 1910 or 1911.

9. **Ardea herodias herodias.** Great Blue Heron.—A large nest of this heron was found in an old Norway pine near the eastern border of the pond (Fig. 10), Charity Island, on July 7. An adult heron was flying about overhead, and while no young could be seen in the nest, the writer was inclined to believe that there were some in the vicinity. On July 20 four young birds were seen and afterward nearly every day during our stay were observed along the beaches. (Figs. 6 and 12). The adult birds made daily excursions to the lines of fish nets until the latter were taken out, about July 15. One was seen on Little Charity Island on July 28.

10. **Butorides virescens virescens.** Green Heron.—This species was not seen in 1910 and only once in 1911. A specimen was found at the edge of the pond on Charity Island on July 8. It probably did not breed as none were observed after that date.

11. **Philohela minor.** Woodcock.—The woodcock was not a common breeder on Charity Island, but at least one pair was observed in May by the assistant keeper, Mr. Singleton. This was near an old garden which is now grown up to willow and alder bushes. In the same place, on July 8, we found the borings, and on June 17 flushed a large adult and an immature bird about half-grown. An adult was also flushed by the writer on July 12.

12. **Pisobia maculata.** Pectoral Sandpiper.—This species was not seen on the islands in 1910, and in 1911 was first seen, on Charity Island, on July 27. When the keepers saw the specimen they both said they had seen and taken some in May 1911. Their absence in 1910 may have been due to the fact that they had passed south before our arrival, on August 16, as the species was seen at Oak Point, on the mainland, on August 24, but not after that date.

13. **Pisobia bairdii.** Baird's Sandpiper.—This is no doubt a not uncommon fall migrant all along the shores of the Great Lakes.[3], [4] The writer saw one on July 9 on Light-House Point, Charity Island, in company with two semipalmated sandpipers. No more were seen although carefully looked for among the few small flocks of waders that arrived at different times in July.

14. **Pisobia minutilla.** Least Sandpiper.—This species is one of the very earliest of the fall migrants and was first seen at Light-House Point, Charity Island, on July 10. Two more were seen at this time in company with semipalmated sandpipers. The species did not become common on Charity Island but was occasionally seen with other small waders.

15. **Pelidna alpina sakhalina.** Red-backed Sandpiper.—This species was not seen on the islands by the writer, and the keepers did not know the bird by name. However, they sent a fine adult female to the Museum, May 25, 1911, and shot another about June 1. In the A. O. U. Check-List the status of this species is given as "rare in migration in the interior of the United States except about the southern end of Lake Michigan." If not equally common throughout the Great Lakes region it certainly is not rare, as the following will show. Taverner says for Point Pelee[5] "It is a late migrant both spring and fall, and is likely both regular and common in its occurrence at the Point." The writer found this species common from Oct. 1 to Oct. 13, 1909, at Point Pelee, flocks of them feeding on the bare mud flats in company with Wilson snipe and killdeer. Jones[6] records it both spring and fall at Cedar Point and says "There is every reason for believing that this sandpiper has been regularly overlooked, and that it occurs in each migration in fair numbers." Todd says for Erie County, Pa.[7] "quite common as a transient visitor in the fall, but rare in the spring." He speaks of extensive flights in former years and of the great numbers killed. "At the present time numerous small flocks are seen sometimes as early as Oct. 2." This species also occurs throughout the interior of southern Michigan and has been taken as early as Sept. 28 (1907) and as late as Oct. 10 (1908) at Ann Arbor. A specimen from Kalamazoo in the Museum was taken May 25, 1878.

16. **Ereunetes pusillus.** Semipalmated Sandpiper.—This sandpiper was the earliest migrant seen on the islands, as two were noted on the point near the Charity Island Light-House on the morning of July 9. These passed on the next day and no more were seen until July 19, when a flock of about fifteen came to the island. After this date it was present during our stay.

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[3] Jones, Lynds. "It was common on August 30, 1890, at Oak Point. I feel confident that this sandpiper is fairly regular in its migration across this region." Birds of Cedar Point. Wilson Bulletin, 1909, p. 126.

[4] Taverner P. A. "On August 24, 1907, we found it almost common. Every bunch nearly of small waders that we saw contained one or more. We never found them in flocks by themselves." Birds of Point Pelee. Wilson Bulletin, 1907, p. 85.

[5] Wilson Bulletin, 1907, p. 85.

[6] Birds of Cedar Point. Wilson Bulletin, 1909, p. 127.

[7] The Birds of Erie and Presque Ile, Erie County, Pennsylvania. Annals of the Carnegie Museum, Vol. II, p. 541.

17. **Calidris leucophaea.** Sanderling.—The sanderling is also an early fall migrant at the islands. A flock of thirteen came to Charity Island on July 19. The birds in this flock seemed to be all or nearly all adults, partly in spring plumage. The next day this flock passed on and no more were seen until July 25, when four immature birds were seen, and a few were present during the rest of our stay.

18. **Helodromas solitarius solitarius.** Solitary Sandpiper.—This bird is one of the earliest migrants at the islands. The writer saw two on the west side of Charity Island on July 10, and after this date it was seen during our stay.

19. **Actitis macularia.** Spotted Sandpiper.—The spotted sandpiper is a very common breeder on Charity Island. In 1911 it bred principally in a colony in the clearing about the light-house, more particularly toward Light-House Point, where a sparse growth of beach grass slightly concealed the nests. The writer found one nest only fifty feet north of the light-house, and ten nests were found among the small willows which occupied the low sand dune between the light-house and the point (Fig. 4). On our arrival, July 5, the young were hatched and were in hiding among the grass and willows near the beaches. When closely approached they would lie motionless on the sand, and the adult bird would fly about overhead, often alighting on the low branches of the oak trees. As the young became able to visit the beaches the writer every day saw dozens leave the cover where they hid, and, when it was quiet, run to the edge of the water and pick up the mayflies that drifted in on the waves. Most of the food was gleaned at the edge of the water. The writer estimated that fifty pairs of birds nested on Charity Island, and there were no doubt many others on Little Charity. This is one of the few species that was seen every day in 1910 and 1911. In 1910 it remained until Sept. 28.

20. **Squatarola squatarola.** Black-bellied Plover.—In his former paper[8] the writer recorded the statement of the keepers that this species had not been noted during the spring migration. In May, 1911, they saw a small flock in full breeding plumage on Charity Island, and these birds did not leave until after June 1. The species is no doubt a more or less regular spring migrant.

21. **Oxyechus vociferus.** Killdeer.—A single pair of this species nested on Charity Island. This is the first time during the thirty years that Captain McDonald has occupied the island that he has observed it as a breeder. The nest contained four eggs and was placed in the light-house clearing, among the loose gravel stones near the dock and only thirty feet from where the keepers passed many times every day. The old bird was never seen on the nest, but three of the eggs hatched on July 4 and the last one on July 5. On the latter date the first three to hatch had left the nest but were not far away as shown by the action of the adults. As the young became older they were seen along the beaches, where they seemed to find all of their food, and by July 30 they were nearly feathered and were able to fly. In 1910 this species was not seen until Aug. 25 and was one of the rarest waders.

22. **Aegialitis semipalmata.** Semipalmated Plover.—An adult female was seen on the point near the Charity Island Light-House, on July 25, in company with four semipalmated sandpipers. After this date from two to five, all apparently adult birds, were seen daily during our stay on the

[8]The Results of the Mershon Expedition to the Charity Islands, Lake Huron: Birds. Wilson Bulletin, 1911, p. 91.

island. In 1910 the species came on August 20, was seen rarely until Sept. 30, and nearly all of the birds were immature.

23. **Arenaria interpres morinella.** Ruddy Turnstone.—The turnstone does not arrive at the islands until after the middle of August. The keepers said that in the spring of 1911 it was more common than ever before noted, and occurred in small flocks as late as June 15. Nearly all of these birds were in spring plumage.

24. **Circus hudsonius.** Marsh Hawk.—On July 7, the writer saw an adult female marsh hawk flying about the south end of the pond on Charity Island, but a careful search did not reveal a nest, and the species was not seen again until July 27 when two flew about the island. On July 28, an adult male was seen but soon passed on to the south. An immature bird was seen on July 29 and three more on July 31, but these also crossed the bay toward Sand Point. The absence of this species as a breeder is explained by the fact that there are very limited areas suitable for nesting sites and very little food in the way of mice, snakes and frogs.

25. **Accipter velox.** Sharp-shinned Hawk.—This species was said to be very common during the spring migration and many were shot by the keepers in 1911. The writer found some of the dried remains of these near the light-house; all were apparently adult birds.

26. **Haliaeetus leucocephalus leucocephalus.** Bald Eagle.— A pair of eagles were observed all summer about Charity Island, and a large nest was found in an old Norway pine near East Point. This nest has been in use for many years and is mentioned by Arnold,[9] who says, "A pair of eagles has nested here for many years." On July 6 and 7 the writer saw a dark-colored bird, evidently a young of the year, on Charity Island. This bird left the island after a day or so, but the two adults were seen nearly every day. They frequented an old, dead Norway pine on the north shore, and often flew out to the lines of fish nets before the latter were taken out, July 15.

27. **Asio flammeus.** Short-eared Owl.—A bird of this species was seen hunting about the light-house clearing on Charity Island early on the morning of July 6. No more were seen until the evening of July 29, when one flew across the clearing. As the cranberry marsh about the pond was flooded, there seemed to be no suitable nesting place, and the species is no doubt only a rare migrant or straggler on the island.

28. **Coccyzus americanus americanus.** Yellow-billed Cuckoo.—A few pairs of this cuckoo lived on Charity Island, and one nest was found in a thick tangle of grape vines on a willow near the edge of the light-house clearing. A pair of birds was seen about this nest nearly every day. The others were scattered about the pond and over the island. It was also observed on Little Charity, July 28, by Dr. Ruthven and the writer. No eggs or young were found as the species is a late breeder.

29. **Coccyzus erythrophthalmus.** Black-billed Cuckoo.—This species did not seem so common as the preceding but was seen July 6 and at various other dates. It was more often heard than seen.

30. **Ceryle alcyon.** Belted Kingfisher.—Kingfishers were seen every day on Charity Island. One pair was generally to be found on the north beach, and another pair seemed to feed about the pond and on the south and west sides. All of these birds seemed to be adult and no nests or young were found, although the birds no doubt bred somewhere along the beaches.

[9]Bulletin of the Michigan Ornithological Club, Vol. IV, p. 74.

31. **Dryobates villosus villosus.** Hairy Woodpecker.—This is a very rare breeder on Charity Island. The only pair seen by the writer (July 17) was in an old Norway pine near East Point. The keepers said that these woodpeckers were more common during the winter, so that some probably come from the mainland during the fall.

32. **Dryobates pubescens medianus.** Downy Woodpecker.—This woodpecker, like the preceding species, is probably a rare breeder on the islands. One pair was seen on Charity Island on July 17, and on July 15 it was heard but not located.

33. **Melanerpes erythrocephalus.** Red-headed Woodpecker.—The red-headed woodpecker is a very rare breeder on the islands. One was heard near East Point, Charity Island, July 7, but none were seen until July 17, when the writer saw an adult and two young of the year on an old dead oak. The young were able to fly from tree to tree. This was probably the only family reared on the island in 1911.

34. **Colaptes auratus auratus.** Flicker.—The flicker was also a rare breeder on the islands. One was heard on Charity Island on July 6 and 8, but the first ones seen were on Norway pines near the path through the woods (Fig. 15), July 12. The first young seen, July 20, were on the sand beach; others were found near the path through the woods on July 25. There seemed to be but two broods.

35. **Chaetura pelagica.** Chimney Swift.—Three pairs of swifts lived in the chimney of the Charity Island Light-House, one flue of which was not used. Sometimes all six of these birds circled about the clearing and were seen to enter the chimney. Often only three were seen, and at times one or two were observed circling about over the forest.

36. **Archilochus colubris.** Ruby-throated Hummingbird.—Only one bird of this species was seen, July 21, but the keepers sent to the museum one found dead on May 20, and said that they were very common in May 1911, thirty being seen at one time at a small apple tree near the lighthouse.

37. **Tyrannus tyrannus.** Kingbird.—This species was a rather common breeder on Charity Island and was seen every day at the edge of the woods and along the beaches. A nest was found on July 7. It was twenty feet above the ground on the top of a stub near Horse Shoe Bay. Another nest was found on July 10 near the same place but fifteen feet from the ground on a horizontal limb of a Norway pine.

38. **Myiarchus crinitus.** Crested Flycatcher.—This flycatcher was a not uncommon breeder on Charity Island, where the many large natural cavities in the trees furnished appropriate nesting sites. A pair was seen, July 6, on the high sand dune between the pond and the west beach, and another pair was seen several times near the path through the woods and at other places on the island. It was not seen on little Charity.

39. **Sayornis phoebe.** Phoebe.—Only one phoebe was seen, July 9. It was in a tree near the light-house clearing on Charity Island. The species probably does not breed on Charity Island but may do so on Little Charity, where there are several old buildings.

40. **Myiochanes virens.** Wood Pewee.—This species was a common breeder on Charity Island. Several pairs were seen after July 7. It was generally found at the edge of the woods but also occurred in the forest, and a pair evidently nested near the edge of the light-house clearing as the birds were often seen feeding there.

41. **Cyanocitta cristata cristata.** Blue Jay.—The blue jay was a rare

breeder on Charity Island. Only one or two pairs were seen, and these kept in the thickest part of the forest and were very quiet. The birds were evidently nesting on our arrival, and it was not until July 24 that the young were noticed. A family of five was seen on that date near the path through the island (Fig. 15).

42. **Corvus brachyrhynchos brachyrhynchos.** Crow.—Next to the spotted sandpiper this species was the most common breeder on Charity Island. The nests were found all over the heavily wooded portion of the island, generally in Norway pine trees. Crows were seen every day and the young were heard on July 8.

43. **Molothrus ater ater.** Cowbird.—The cowbird was very rare on Charity Island and no doubt occurred only as a straggler from the mainland. One was seen near the clearing on July 12, and three others on July 21.

44. **Quiscalus quisculus aeneus.** Bronzed Grackle.—This species may have bred on Little Charity Island but evidently did not do so on Charity, as it was seen on but two occasions. On July 6, three flew over the clearing, and on July 10 a flock of about twenty was seen at the same place. No nests were found.

45. **Astragalinus tristis tristis.** Goldfinch.—The goldfinch is an uncommon summer resident and breeder on the islands. A pair was seen July 7, on the beach at Horse Shoe Bay, Charity Island, and a few more were observed at later dates. No nests were found, probably because the species is a late breeder. Doubtless very few breed on the island, as the food supply is very limited. The thistle, which furnishes much of the food of the species in this region, is quite uncommon.

46. **Poœcetes gramineus gramineus.** Vesper Sparrow.—This species was a very rare summer resident and breeder on Charity Island, but it was more common on Little Charity no doubt because of the more open conditions there. A pair was seen in the Charity Island clearing on July 6, where it no doubt nested. It was quite common on Little Charity on July 28.

47. **Spizella passerina passerina.** Chipping Sparrow. The chipping sparrow was not seen on Charity Island in 1910, and but one pair was found in 1911. This pair evidently nested at the edge of the clearing. At Little Charity Island the species was common on July 28, probably for the same reason that the vesper sparrow was common there.

48. **Spizella pusilla pusilla.** Field Sparrow.—This sparrow is also a rare breeder on Charity Island, for only one pair was found (July 22). These birds were on the open sand dunes of the southern part of the island (Fig. 8). It was more common on Little Charity, where several were seen on July 28.

49. **Melospiza melodia melodia.** Song sparrow.—Only one or two pairs of song sparrows were found on Charity Island. These were about the light-house clearing and were seen and heard singing nearly every day. The first young bird was seen on July 25. The species was common on Little Charity.

50. **Passer domesticus.** English Sparrow.—This species was seen but once, on July 29, at the light-house clearing on Charity Island. These birds came from the west side of the bay, probably from Point Lookout.

51. **Passerina cyanea.** Indigo Bunting.—The indigo bunting was more common than the sparrows on Charity Island, and several pairs were seen at the edge of the woods about the island. Two adult males were

seen on July 6 and others on July 7 and 8. The first female was seen on July 12, and one was found dead on the platform under the light on July 26. Nine were seen on Little Charity, where it may have bred.

52. **Progne subis subis.** Purple Martin.—This species did not breed on Charity Island, but a pair was seen on July 6 and several times later. They were generally observed flying about over the light-house clearing. On July 28, a pair was seen at Little Charity, where there was a martin box on top of the fish houses. The birds observed on Charity Island very probably came from Little Charity.

53. **Petrochelidon lunifrons lunifrons.** Cliff Swallow.—This species did not breed on the islands, but two were seen flying about the Charity Island Light-House on July 6 and four on July 9 and 10. These were seen with flocks of barn swallows that frequently flew about the clearing.

54. **Hirundo erythrogastra.** Barn Swallow.—Only one pair of barn swallows bred on Charity Island. These started to build in the boat house where they were not wanted, and the keepers tore down two partly built nests. A nest was then started over the window in the poultry house and was completed during the latter part of our stay. The species was more common on Little Charity, where it nested in the old houses. A flock often came to Charity Island, especially in the morning.

55. **Iridoprocne bicolor.** Tree Swallow.—The writer saw single pairs of tree swallows on July 6 and July 10 near the Charity Island Light-House. No nests were found, and it was not seen often enough to indicate that it probably bred here.

56. **Riparia riparia.** Bank Swallow.—This species evidently did not breed on the islands although there was a high sand bank on the west beach of Charity Island. After July 17, the writer saw from four to thirty each day, flying and feeding over the clearing on Charity Island. The species was not recorded from the islands in 1910, no doubt because it had ceased to visit the islands before the date of our arrival (August 16).

57. **Bombycilla cedrorum.** Cedar Waxwing.—The cedar waxwing was a rather common breeder on Charity Island. A flock was seen on July 7, feeding in poplar trees, and several others on later dates and at different parts of the island. On July 25, a pair was seen to commence a nest in a small willow bush near the garden in the light-house clearing.

58. **Vireosylva olivacea.** Red-eyed Vireo.—This species was one of the most common breeders on Charity Island and was seen nearly every day of our stay. It was observed all over the island, and one nest was found at the edge of the light-house clearing.

59. **Dendroica aestiva aestiva.** Yellow Warbler.—The yellow warbler was first seen on July 20, when three were observed among the willows near Light-House Point on Charity Island. No nests were found and no birds seen until the above date, and the writer is inclined to consider that the ones noted were migrants from the mainland.

60. **Dendroica virens.** Black-throated Green Warbler.—This warbler did not breed on the islands, but one was seen in the pines near the Charity Island clearing on July 27. It was no doubt a migrant from the mainland west of the bay, where it is known to breed.

61. **Setophaga ruticilla.** Redstart.—The redstart was a not uncommon breeder on Charity Island. Adults and young were seen nearly every day in July.

62. **Dumetella carolinensis.** Catbird.—This species was evidently a very uncommon breeder on Charity Island. It was only seen in a willow

thicket near the light-house. One nest was found, and there seemed to be but one pair of birds on the island. One was seen on Little Charity on July 28.

63. **Thryothorus ludovicianus ludovicianus.** Carolina Wren.—This species is an addition to the Charity Island list. A single bird was seen on July 25 by the writer, and Dr. Ruthven heard one singing early in the morning of July 28 near the light-house, where the first one was taken. We have no knowledge of this species in Michigan north of this latitude.

64. **Sitta carolinensis carolinensis.** White-breasted Nuthatch.—This nuthatch was not common on Charity Island, and only one or two pairs were seen. On July 13 the writer saw a pair of adults, with young, feeding among the Norway pines along the path through the woods.

65. **Penthestes atricapillus Atricapillus.** Chickadee.—The chickadee was not a very common resident and breeder on Charity Island, but two or three pairs were seen, on July 6, 7 and 8, near the edge of the woods. On July 20, several (evidently a family) were seen on low willow bushes at the end of South Point. When "called," this species would come about us and often alight within a few feet, seeming anxious to find out what it was all about. This is one of the very few species that winter on the islands.

66. **Planesticus migratorius migratorius.** Robin.—The robin is a very rare summer resident on Charity Island. Only one pair was noticed. One was heard singing on July 19 near East Point, five, evidently a family, were seen on July 27, and six were observed on July 29.

NOTES ON THE WISCONSIN WOOD FROG.[1]

BY HELEN B. THOMPSON.

The Wisconsin wood frogs have been reported as *Rana temporaria* L. var. *sylvatica* LeConte, Smith[2] and Higley,[3] and *Rana sylvatica* LeConte, Hay[4] and Cope.[5] Miss. Dickerson[6] states that *Rana cantabrigensis* has been reported from Wisconsin, but the writer has been unable to verify this.

In examining a series of wood frogs from Wauwatosa, Wis., belonging to the Public Museum of Milwaukee,[7] and labeled *R. sylvatica*, the writer has found that they are to be referred to the species *cantabrigensis*, the length of the hind limb to the heel either equalling or only slightly exceeding the total length of the head and body. In the typical *R. sylvatica* the legs are much longer, the length to the heel being considerably greater than the entire length of the head and body. There are also three wood frogs from Racine, Wisconsin, in the University of Michigan Museum that are to be referred to the same species. This would indicate that the Wisconsin wood frog is the northern rather than the eastern form.

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[1]From the University of Michigan Museum of Natural History.
[2]Geol. Surv. Ohio, IV, Part I, 1882, p. 710.
[3]Trans. Wis. Acad. Sci., II, 1889, p. 168.
[4]Geol. Surv. Wis., I, 1883, p. 425.
[5]Bull. U. S. Nat. Mus., No. 34, 1889, p. 450.
[6]The Frog Book, 1906, p. 212.
[7]I am indebted to Mr. Henry L. Ward, director of the museum, for the opportunity of studying this material.

THE STATUS OF RANA PALUSTRIS LECONTE IN MICHIGAN.[1]

BY CRYSTAL THOMPSON.

Little is known of the distribution of the frog *Rana palustris* in Michigan. Sager[2] lists it from Michigan but gives no localities. Smith[3] records it from Ann Arbor, and later, in his report on the reptiles and amphibians of Ohio[4], records it from Michigan in general. Cope[5] reports a single specimen from the Detroit River, but this specimen is in the University of Michigan Museum and has been re-identified as *Rana pipiens*. Gibbs, Notestein and Clark[6] report it from Detroit, Kalamazoo, Montcalm and Van Buren Counties, but unfortunately the specimens from which these records were made have not been preserved.

On April 20, 1911, Helen Thompson and the writer collected a single specimen from White's Woods near Ann Arbor. Later several others were collected both by other persons and the writer in the vicinity of Ann Arbor. In working over the collection of amphibians in the museum, three specimens from Brighton, Livingston county, Michigan, were found. One of these was taken from the stomach of a garter snake, *Thamnophis sirtalis*. Two large specimens taken near Hastings, Barry County, in May, 1911, were received from Miss Jessie McNall, and the writer collected about fifty specimens in Cass County in May, 1911. The Cass County specimens were all of rather small size but were very typical. The majority of them were taken along a ditch which runs thru a low marshy region. Others were taken about the outlet of a spring on the bank of Long Lake. On August 29, 1911, the writer collected a specimen on the bank of the Kalamazoo River in Calhoun County, and on August 30 another was taken in a similar location in Kalamazoo County.

It will be seen from the above records that our knowledge of the distribution of this form within the state is very limited, and that more data in regard to it are greatly to be desired.

Altho *Rana palustris* is frequently confused with the more common *R. pipiens* the differences between them are so great that even the most casual observer should have no trouble in distinguishing them. *R. palustris* may be easily identified by the rectangular shape of the spots on the back and sides. The ground color is more brownish than that of the typical *R. pipiens*, and there are two distinct rows of rectangular darker spots between the lateral folds and two rows of more or less rectangular spots on either side below them. The folds themselves are very broad and not elevated as in *R. pipiens*. The under part of the hind limbs is tinged with bright yellow and this color may even extend along the sides of the abdomen.

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[1]From the University of Michigan Museum of Natural History.
[2]Report of the State Zoologist. Senate Documents, Mich., 1839, 294-305.
[3]Catalogue of Reptilia and Amphibia of Michigan. Supplement to Science News. 1879.
[4]Geol. Surv. of Ohio, 1882, IV, Part I, 709.
[5]Bull. U. S. Nat. Mus., 1889, 406-409.
[6]Seventh Ann. Rept. Mich. Acad. Sci., 1905, 109.

NOTES ON PHYLLOPOD CRUSTACEA.

A. S. PEARSE, HONORARY CURATOR OF CRUSTACEA, UNIVERSITY OF MICHIGAN MUSEUM.

A small collection of phyllopods in the collection of the University of Michigan Museum was turned over to the writer for examination. The following notes include descriptions of three species that appear to be new and some points of interest concerning six others.

Thanks are due Dr. G. S. Dodds and Professor C. W. Hargitt, who sent specimens from Colorado and New York respectively.

Eubranchipus dadayi sp. nov.

Male: First *antennae* slender, longer than eyestalk. *Frontal appendages* lanceolate, resembling those of *E. ornatus* Holmes; both margins lobate, the lobes most pronounced on middle; usually rolled into a cylindrical form; inner surface of appendage and lobes denticulate. *Second antennae:* basal segment armed with a rounded tubercle at proximal end of inner margin; terminal segment as wide as basal segment at proximal end with a strong sinuous finger-like process projecting inward from the inner margin near proximal end; this process is half as long as the segment that bears it and its tip is roughened; terminal segment narrow in middle, enlarged and abruptly truncated at tip.

Abdominal segments not narrowed in front or produced backward at their posterior angles, the last segment slightly wider distally than those preceding it. *Penial appendages* curved outward with teeth along distal portion of outer margin; basal portions bearing denticulate processes that meet in the median line.

Female: None of the lateral margins of the segments are produced posteriorly. The second antennae end is an acute process that is directed outward.

Length of largest individual, a female; 21 mm.

The types, six females and five males (Michigan Museum, No. 40527), were collected by the writer at Lincoln, Nebraska, April 20, 1899. This species was also collected at St. Louis during the spring of 1912.

Eubranchipus gelidus (Hay).

Through the kindness of Professor C. W. Hargitt the writer was able to examine six females and four males collected near Syracuse, New York (42313). As this species has never been figured four cuts are presented which show the male appendages and clasping organs as well as the peculiar processes on the last two pregenital segments of the female.

Branchinecta packardi sp. nov.

Male: Body slender; no lateral spines. Basal segment of *second antennae* produced and spiny at inner proximal angle; a prominent finger-like process with a tuberculated tip arises on the anterior surface near

this angle; a large spiny process one-third as long as the segment arises just distal to the center of the inner margin and projects proximally. Terminal segment of second antenna arcuate, concave on inner surface, curved inward at tip. *Eyes* of medium size. *Penial appendages* cylindrical, bearing one dentate process at the inner distal angle and another near it on the inner margin; a sharp spine on the outer margin near the proximal end. *Caudal appendages* slender (more slender than in *B. lindahli* or *B. coloradensis*).

Female: The five pregenital segments are produced laterally into strong spinous processes which grow larger posteriorily. The *second antennae* are slender, lanceolate and curved slightly outward at tip. *Ovisac* reaching to middle of sixth post-genital segment; eggs small.

Length—Male, 16 mm.; female, 17.2 mm.

This species is described from eight males and three females (42360) collected in a pool at La Junta, Colorado, by Dr. G. S. Dodds. It is named for Professor A. S. Packard who contributed so largely to our knowledge of North American phyllopods.

Streptocephalus texanus Packard.

Dr. G. S. Dodds collected two males of this species (42357) from a pool near Ward, Colorado, at an altitude of 9,000 feet; and a single female (42358) associated with *Thamnocephalus platyurus* Packard from a pool near La Junta, Colorado. The writer collected a male (40526) and two females (40524) at De Witt, Nebraska, in 1896.

Thamnocephalus platyurus Packard.

Two males and a female (42359) were collected by Dr. G. S. Dodds in a "cattle pool" that had been filled with water from an irrigating ditch at La Junta, Colorado. These specimens are larger than those collected for Packard in Kansas; the males measure 31.5 mm. and the females 36 mm. in length.

Apus aequalis Packard.

This species was extremely abundant at De Witt, Nebraska, during the spring and summer of 1896 and between two and three hundred specimens of various sizes were collected (40517, 40518, 40521, 40535, 40531, 40532). The length varies from 15 to 34 mm. In smaller individuals 22 or 23 somites are exposed behind the carapace, and in larger specimens there may be as many as 26. The length of the carapace at the median line is about equal to the portion of the body exposed behind. The armature of the telson is somewhat variable; on the dorsal side there is commonly one median spine, but there are often two; there are usually two lateral spines at the proximal edge of the telson, but there are frequently more.

Estheria mexicana Claus.

Ten specimens (40533) were taken from a pool near Salt Creek on H. Street in Lincoln, Nebraska, on October 13, 1894.

Estheria morsei Packard.

About fifty specimens (40520, 40522, 40523) were collected at De Witt, Nebraska, in 1896.

Estheria setosa sp. nov.

Female: Shell globose with prominent umbones at end of anterior third; dorsal margin straight for one third length of shell behind umbones; anterior and posterior margins rounded. Thirteen lines of growth. The margin of the shell is armed with subequal setae which grow smaller toward anterior end, and several of the adjoining lines of growth may have similar setae, particularly at the posterior end. Coarse granular markings between the lines of growth, these are arranged irregularly and are more abundant in each space toward the outer margin of the shell.

Second *antennae* with 14 segments in the upper and 15 in the lower flagellum. Seventeen spinous processes occur along the back anterior to the telson. These have the following number of setae, beginning at the anterior end: 1, 1, 3, 5, 9, 9, 9, 9, 7, 7, 4, 3, 3, 3, 3, 3, 1; all these setae are directed posteriorly and those on processes 2-10 are long and attenuate. Upper border of *telson* with thirteen unequal teeth in addition to those at either end; two long setae near the proximal end. Caudal appendages slender, minutely denticulate on inner margin, proximal half setose on inner margin.

Size of shell: length, 5.3; width, 2.3; height 3.2 mm.

Fifteen females (40524, 40528) of this species were collected at De Witt, Nebraska, in 1896. No males were taken. The species resembles *E. belfragei* Packard in the number of segments in the antennal flagella, but differs from Packard's species in the shape of the shell, the number of lines of growth, and other particulars. The name *setosa* is given to it on account of the length of two setae which it bears near the proximal end of the dorsal margin of the telson.

Eulimnadia texana Packard.

About two hundred individuals (40530, 40534, 40535) were taken at De Witt, Nebraska, in 1896. In these specimens the first antenna reaches to the second article of the flagellum of the second antenna. The flagella of the second antenna are 8-to 10-segmented; there are from 16 to 22 teeth on the dorsal border of the telson, and five lines of growth.

EXPLANATION OF FIGURES.

Plate 1.

Eubranchipus dadayi sp. nov.

Fig. 1. Posterior view of head of male.
Fig. 2. Anterior view of head of female.
Fig. 3. Frontal appendage of male.
Fig. 4. Penis.
Fig. 5. Clasping antenna of male.

Plate 2.

Fig. 6. *Eubranchipus gelidus* (Hay). Side view of head of male.
Fig. 7. *Eubranchipus gelidus* (Hay). Clasping antenna of male.
Fig. 8. *Eubranchipus gelidus* (Hay). Posterior portion of female.
Fig. 9. *Eubranchipus gelidus* (Hay). Frontal appendages of male.
Fig. 10. *Estheria setosa*. sp. nov. Shell.
Fig. 11. *Estheria setosa*, sp. nov. Posterior end of body.
Fig. 12. *Estheria setosa*, sp. nov. Second antenna.

Plate 3.

Branchinecta packardi sp. nov.

Fig. 13. Head of male; posterior view.
Fig. 14. Basal segment of right second antenna of male; anterior view.
Fig. 15. First antenna of female.
Fig. 16. Second antenna of female.
Fig. 17. Penial appendage of male.

NOTES ON MICHIGAN CRUSTACEA. II.

A NEW MICHIGAN ASELLUS.

BY A. S. PEARSE, HONORARY CURATOR OF CRUSTACEA, UNIVERSITY OF MICHIGAN MUSEUM.

On March 10, 1911, Miss Mae Williamson collected three isopods, two males and a female, from a ditch at Steere's Swamp, south of Ann Arbor (University of Michigan Museum number 42312). The specimens were given to the writer for identification and proved to belong to a species not previously recorded from this state,—**Asellus intermedius** Forbes. This species is readily distinguished from the other Michigan Asellus (*A. communis* Say) by possessing small lateral lobes on the head near the posterior angle, by the 7-segmented flagella on the first antennae, and by the longer second antennae which extend to the posterior margin of the seventh thoracic segment. Its occurrence in a swampy ditch in Michigan is of interest for it has previously been reported from only two localities:—"in hill country in southern Illinois, under stones in small streams," and from "the Potomac River near Washington."[1]

[1]Richardson, H. 1905. A Monograph of the Isopods of North America. Bull. U. S. Nat. Mus. 54, liii. 727 pp.

PLATE 1.

1

2

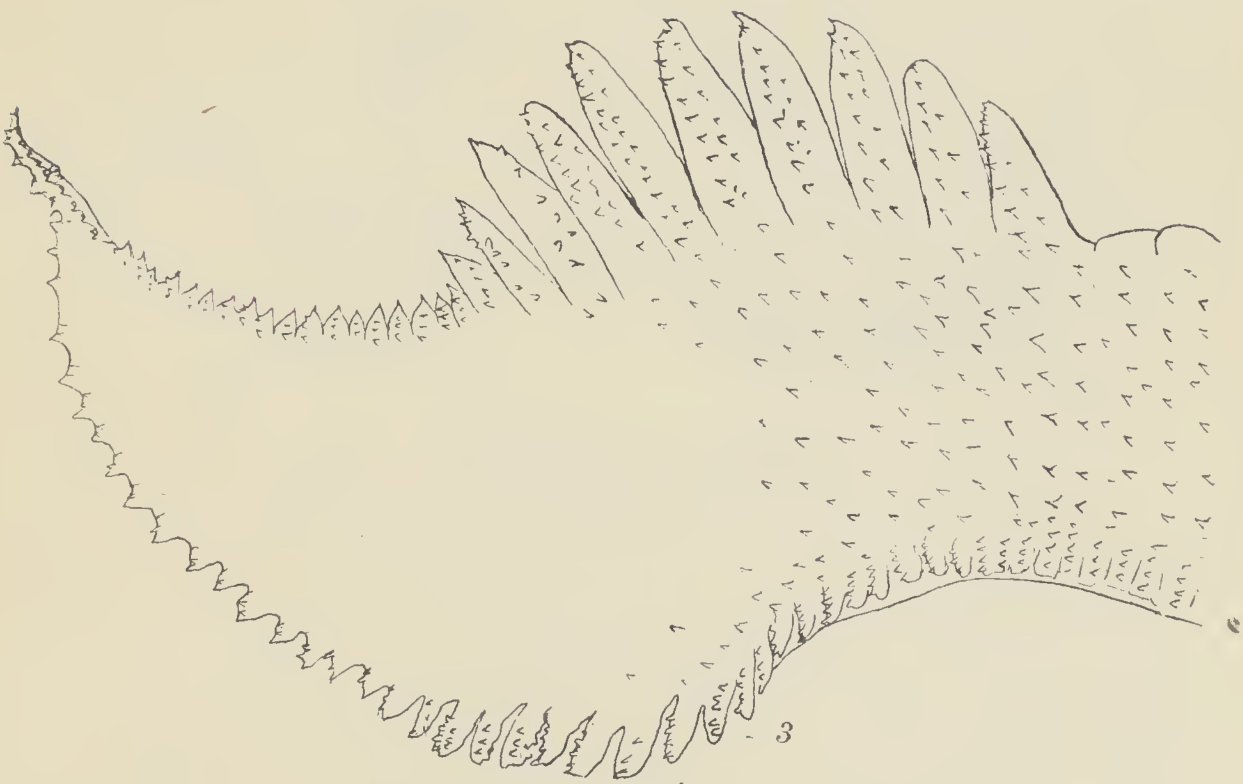

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PLATE 2.

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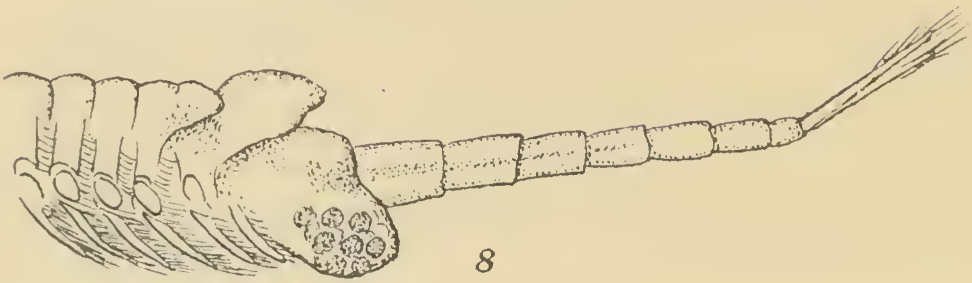

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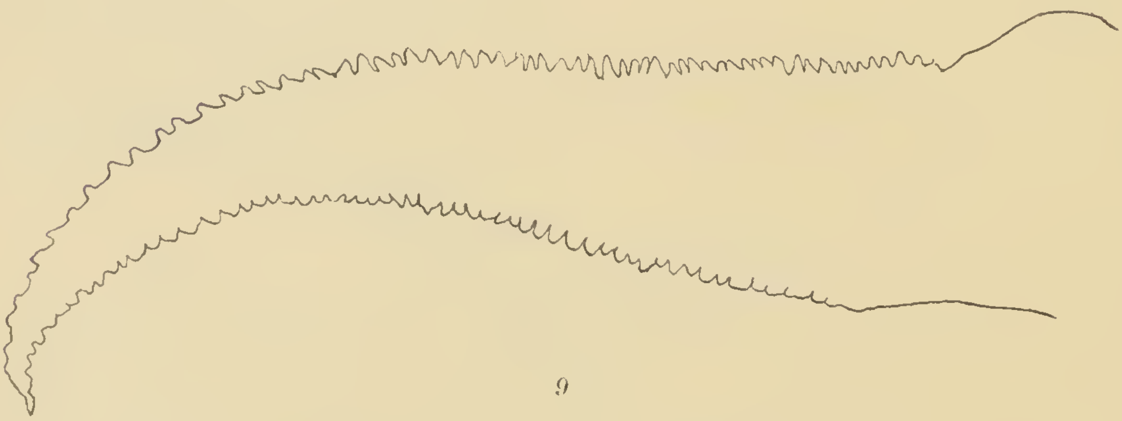

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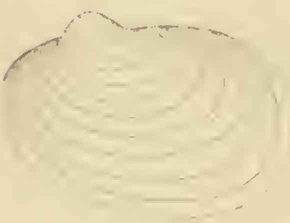

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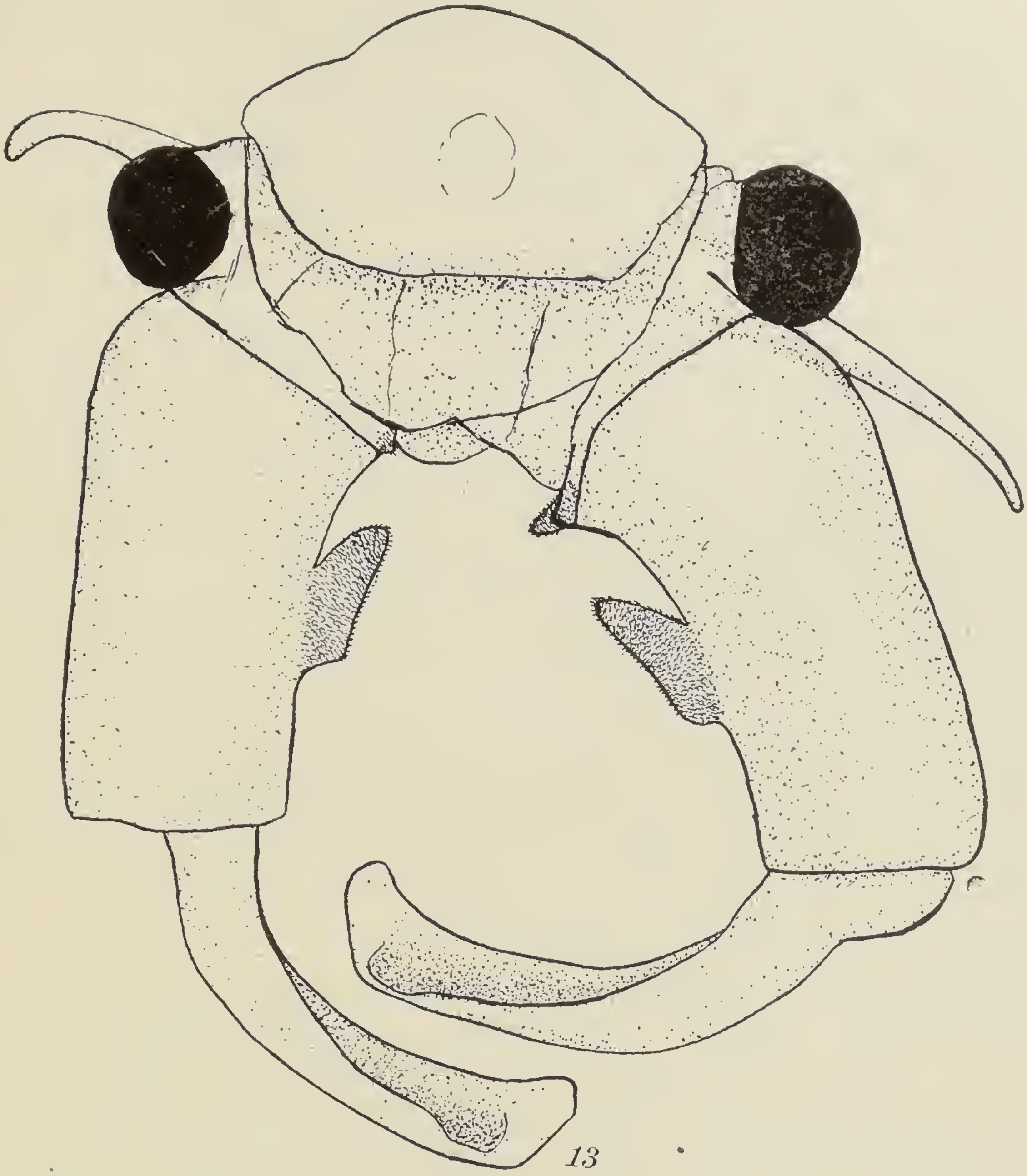
PLATE 3.



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A COLLECTION OF MAMMALS FROM OSCEOLA COUNTY, MICHIGAN.[1]

BY ORRIN J. WENZEL.

This paper is the result of field work carried on during the summer and autumn of 1911 for the Michigan Geological and Biological Survey, supplemented by observations made by the author during several years residence in Osceola County.

The region consists principally of sandy moraines which thirty or forty years ago were covered with pine. Scattered about thruout this sandy region are small areas of heavy clay, varying from less than a township in length to tracts large enough to extend nearly across the county. Such areas were originally covered with hardwood and are now either cultivated or are still occupied by hardwood or hardwood slashings. There are many lakes varying in size from one or two acres to one or two thousand. Those in the typical pine land usually have sandy shores, while those in the hardwood areas are surrounded by bogs.

In the course of the work, the varied conditions observed were classified into general habitats, and the habitats were then studied with reference to the mammals inhabiting them. The collecting of specimens was not given most attention, only a sufficient number being taken to insure proper identification of the species, but considerable attention was paid to the habits and the present status of each species, i. e., abundance and whether increasing or decreasing in numbers.

The specimens taken are preserved in the University of Michigan Museum, and the numbers in the list of species are those which have been given to them in the museum catalog. Where no specimens were taken, the writer has taken considerable care that the reports are reliable. This paper does not then purport to be a complete list of the mammals of the region, but an accurate and reliable record of most of them. It is hoped that students of the general fauna of the state and all others interested in mammals may find this paper of assistance and interest.

I am indebted to Dr. Alexander G. Ruthven for helpful suggestions and criticisms in the planning of the field work and in the preparation of this report, and to Mr. Norman A. Wood for help in the identification of some of the more difficult species. I wish also to acknowledge my indebtedness to William Allen and his son James Allen, of LeRoy, for the loan of the latter's mounted specimens of badger, raccoon and woodchuck, the photographs of which appear in this report. The men who have contributed valuable information are Wm. Allen, Bert Byam, Adelbert Roberts and A. C. Stieg.

DESCRIPTION OF HABITATS.

All existing conditions found in the region were grouped for convenience into seven major habitats as follows: Pinery or Pine Slashings, Hardwood Forest, Farm-land, Tamarack and Cedar Swamps, Sphagnum Bogs, Lake

[1]Published by permission of Alexander G. Ruthven, Chief Field Naturalist, Michigan Geological and Biological Survey.

Margins and Streams, Marsh-land. Wherever similar conditions existed, altho miles apart, they were grouped under one head, and, therefore, the descriptions must necessarily be composite pictures, so to speak, of all places where similar conditions exist. It will be seen at once that these habitats may vary widely within themselves, but in each one it is believed that the conditions are sufficiently uniform to make the fauna quite homogeneous in each general habitat, and this was borne out by the study of the species.

PINERY OR PINE SLASHING HABITAT.

(Figs. 1-4.)

All of the territory grouped under this heading was originally covered with a pure stand of pine, most of which was removed about twenty years ago or before. Since then it has been burned over repeatedly at intervals of several years. At present, trees are very scarce; small oaks, poplars, cherries, and an occasional pine are the only representatives. Sumacs, brake fern, black-berry bushes which never bear good berries, a few huckleberry bushes, sweet-fern, winter green and june grass make up the greater part of the flora.

Red foxes are quite plentiful in this habitat. Besides this species, mole tunnels are quite frequently seen and within the last few years the thirteen striped spermophile has made steady progress into this sort of habitat, notwithstanding the large numbers of its enemy the red fox. Other species that frequent these conditions are the deer, woodchuck and white-footed mouse.

HARDWOOD FOREST HABITAT.

(Figs. 5-8.)

Under this habitat has been included all the land which once bore hardwood, excepting that which is now under cultivation. For convenience in this study, it was subdivided into virgin hardwood forest and second growth or hardwood slashings.

The hardwood forest of the general region (beech, maple and hemlock association) is too well known to need detailed description. Unfortunately very little of this primitive forest is left. In the areas studied the mammals observed were: fox squirrel, gray squirrel, red squirrel, flying squirrel, chipmunk, white-footed mouse, jumping mouse, porcupine, weasel, and shrew.

By far the greater part of the hardwood habitat consists at the present time of second growth or recently cut hardwood especially the latter. About the first plants to grow after the timber is cut are the red and black raspberries, choke-cherries and saplings of the same species as those cut. The mammals observed here are: red squirrel, chipmunk, spermophiles, woodchuck, flying squirrel, white-footed mouse, cottontail, weasel, shrew, mole, skunk, and badger.

FARM-LAND HABITAT.

(Figs. 9-10.)

This habitat includes all land under cultivation. It consists, to the greater extent, of land which has been cleared of hardwood, the pine land being little utilized at present. There are many stone piles, fence rows

and piles of rubbish which make very desirable hiding places for many of the smaller mammals, while the grain fields furnish an abundance of food for many forms. The following mammals were observed here: spermophile, woodchuck, white-footed mouse, meadow mouse or vole, cottontail, skunk, badger, shrew, and mole.

SPHAGNUM BOG HABITAT.

(Fig. 11).

By far the larger number of lakes in the region studied are surrounded by sphagnum bogs, with their typical bog associations of sphagnum, pitcher plant, cranberry, leatherleaf etc., which are so well known thruout the state. The bogs are singularly free from all forms of mammalian life, except when they are combined with the tamarack and cedar swamp habitat, which I have chosen to separate from the more typical bogs altho they have many points in common. The star-nosed mole and perhaps the lemming vole are about the only mammals which probably inhabit such places.

TAMARACK AND CEDAR SWAMP HABITAT.

(Figs. 12-13).

The environic conditions found in this habitat appear next in the natural succession of plant associations following the bog. In fact, along the margins of some of the lakes one may easily find all transitions between the two. The trees are mostly balsam, cedar and tamarack. Many kinds of mosses are found besides the sphagnum which is always present in the wetter swamps. Liverworts (Marchantia and Conocephalus) are found in considerable abundance. The mammals are: red squirrel, chipmunk, flying squirrel, white-footed mouse, varying hare, cottontail, wildcat, gray fox, mink, weasel, shrew, and starnosed mole.

MARSH-LAND HABITAT.

(Fig. 14.)

During the early spring, the land classified as marsh land is entirely covered by water. This dries up to a greater or less extent in summer, and tall coarse grass and sedges grow densely and to a very large size. Cattails often grow in the wetter portions.

All of the mammalian forms which are found here must necessarily migrate back and forth with the rise and fall of the water. Meadow voles and shrews are usually found in such places thruout the summer, and muskrats usually occur in great numbers during the wet seasons, unless the marsh becomes too dry at one season and at the same time is too far away from other water for the muskrats to migrate.

LAKE MARGIN AND STREAM HABITAT.

(Figs. 15-16).

It is evident that this division may contain all of the conditions of the other habitats. Its only point of difference from all the others is the presence of water; and this alone is responsible for its characteristic fauna. The characteristic species are: muskrat, mink, and weasel.

LIST OF SPECIES.

1. **Odocoileus americanus borealis** Müller. Northern White-tailed Deer.—Deer have become quite rare in the region of Osceola County, but recently, owing to the closed season for several years, they seem to be slowly increasing. A few are killed each year by local hunters.

2. **Sciurus niger rufiventor** (Geoffrey). Western Fox Squirrel.—Fox squirrels are quite plentiful wherever any hardwood timber remains. This species seems to be replacing the gray squirrel, which has been nearly exterminated within the past few years.

MEASUREMENTS.

Museum Number	Sex	Length	Tail	Foot
42186	female	525 mm	217	70
42187	"	565	252	75

3. **Sciurus carolinensis leucotis** (Gapper). Northern Gray or Black Squirrel.—Within the last fifteen years, squirrels of this species were so plentiful in Osceola County that it was not unusual for a hunter to kill from ten to twenty in a single day. Among these the black phase was predominant. Today, they are among the rarest of our mammals and only to be found in the largest tracts of hardwood forests. The black phase still predominates.

4. **Sciurus hudsonicus loquax** (Bangs). Red Squirrel, Chickaree.—Abundant and of general distribution.

MEASUREMENTS.

Museum Number	Sex	Length	Tail	Foot
42168	female	327 mm	135	51

5. **Tamias striatus lysteri** (Richardson). Lyster's Striped Chipmunk.—Abundant and of general distribution.

MEASUREMENTS.

Museum Number	Sex	Length	Tail	Foot
42171	female	235 mm	86	35
42172	"	234	88	35

6. **Citellus tridecemlineatus** (Mitchell). Thirteen-Striped Spermophile.—This species, unknown in this region up to a few years ago, has become very plentiful in the county. It is found in considerable numbers thruout the waste pine and hardwood lands, but its economic importance can not be appreciable for its presence in the cultivated regions is hardly noticeable. Seeds constitute the main diet; as many as seventy-seven seeds resembling those of the sunflower and measuring approximately 3×5 mm were taken from the cheek pouches of one specimen. Many places were found where foxes and badgers had dug them out of their burrows, and domestic cats kill numbers of them in the vicinity of human habitations.

MEASUREMENTS.

Museum Number	Sex	Length	Tail	Foot
42169	male	244 mm	78	35
42170	"	238	78	35

7. **Marmota monax** (Linnaeus). Woodchuck.—These animals are not so plentiful as formerly. Their scarcity is probably due to the abundance of foxes and badgers which seem to be their only important enemies excepting man. Only one specimen was observed, and this one was caught and escaped three times from number $1\frac{1}{2}$ steel traps before it left the stone pile under which it lived. Many insects and even mice have been taken from the stomachs of this species of rodent. (Roberts.) (Fig. 17.)

8. **Sciuropterus sabrinus macrotis** Mearns. Hudson Bay Flying Squirrel. —Flying squirrels are found in considerable numbers when trees are cut down, altho they are seldom observed at other times. Several are usually to be found together in the same hollow tree. The specimen taken, altho not quite full grown, shows the plumbous color underneath when the fur is parted, which is characteristic of the form.

MEASUREMENTS.

Museum Number	Sex	Length	Tail	Foot
42167	female	240 mm	112	34

9. **Peromyscus leucopus noveboracensis** (Fischer). Northern White-footed Deer Mouse.—This mouse is found in considerable numbers in almost all of the habitats except the bogs.

MEASUREMENTS.

Museum Number	Sex	Length	Tail	Foot
42173	male	150 mm	78	20
42174	"	160	75	21
42175	?	173	84	21
42176	male	175	82	20
42177	female	167	75	20
42178	male	146	70	20

10. **Microtus pennsylvanicus** (Ord). Meadow Mouse.—The meadow mouse is well represented thruout the cultivated regions.

11. **Fiber zibethicus** (Linn.) Muskrat.—This species is very numerous thruout Osceola County, no doubt because of the abundance of small lakes, ponds, streams, and marshes which are flooded the greater part of each year.

A small shelf, a few inches in diameter, which the muskrats used as a feeding place was closely observed. It was located under the root of a tree which had tipped away from the water's edge to an angle of 45°. The feeding place was therefore accessible only from the water. The whole space under the root was literally covered with pieces of the stems, flowers, and leaves of the yellow water lily, stems of another plant resembling boneset (not identified), and the shells of the fresh water mussels. The shells were well covered with teeth marks. The writer was told that large piles of such shells are often found, and that dead fish are often used by trappers as bait for muskrats (Roberts).

Mr. Peterson, on whose farm (situated one mile west of LeRoy) there is a small pond, says that muskrats inhabiting this pond become a nuisance, as they catch young poultry, especially ducks, and also because they burrow back into the adjoining fields to such an extent that areas several feet in diameter are caused to cave in. That muskrats do capture young

poultry does not seem improbable since it is said that "hunters occasionally find muskrats feeding on the bodies of waterfowl that have been shot and lost in the marshes."[1]

MEASUREMENTS.

Museum Number	Sex	Length	Tail	Foot
42184	female	557	230	75

12. **Zapus hudsonius** (Zimmerman). Hudson Bay Jumping Mouse.—The writer has observed these animals on one or two occasions in previous years, but none were seen in 1911.

13. **Erethizon dorsatum** (Linn.) Canadian Porcupine.—These animals have disappeared with the hardwood and hemlock forests until at present they are very rare. They are most plentiful in the northern part of the county and in southern Wexford County, where there are small islands, so to speak, of hemlock and hardwood isolated from the surrounding region by thousands of acres of almost impenetrable tamarack swamp. One specimen was taken.

Museum Number 42181. Sex female.

14. **Lepus americanus** Erxleben. Varying Hare.—This hare is quite plentiful at present, altho the numbers are slowly decreasing. It is only found in the vicinity of large tamarack swamps or far in the interior of the waste lands, where there is a large amount of second growth trees, especially the aspens, oaks, etc., which are invading the "pineries," and then only when there is swampy or low ground in the vicinity. One specimen was taken by the writer in the winter of 1910-11.

Museum Number 41764. Sex male.

15. **Sylvilagus floridanus mearnsi** (Allen). Cottontail.—Cottontails are to be found everywhere in the hardwood habitat, in the tamarack swamps, and in the margins of the pine lands. Merciless persecution by hunters and the presence of numerous enemies do not seem able to cause any decrease in the numbers.

MEASUREMENTS.

Museum Number	Sex	Length	Tail	Foot
42182	female	455 mm	40	110
42183	male	400	45	100

16. **Felis canadensis** (Kerr). Canada Lynx.—It is somewhat doubtful if this species is ever found at present in Osceola County, altho reports are occasionally started that one has been seen. There is no record on the books of the County Clerk of a bounty having been paid on a lynx within the last fifteen years. This, however, is not good evidence since many such specimens go to the taxidermist and not to the County Clerk.

[1]David E. Lantz, "The Muskrat," Farmers Bulletin, 396, U. S. Dept. Agriculture.

17. **Felis rufa** Gueldenstaedt. Red Lynx, Wild Cat.—That wild cats still exist in small numbers in the denser tracts of timber and swamps is not to be doubted. Altho there is only one record of a bounty being paid within the last fifteen years (1910), several more have been seen and killed to the writer's certain knowledge.

18. **Vulpes fulva** (Desmarest). Red Fox.—Red foxes are very plentiful in the waste pine lands. They live upon rabbits, birds, mice, woodchucks, and spermophiles and seldom if ever molest farmers' poultry. It is not probable that there will be any decrease in their numbers so long as there are such vast areas of waste land where they can live and breed relatively unmolested.

19. **Urocyon cinero-argenteus** (Schreber). Gray Fox.—This species is not so well represented by far as it was a few years ago. Altho a southern form, it is found at present almost entirely within or near the large "boreal islands" (tamarack and cedar swamps), which furnish it the best protection. The writer killed perhaps a dozen of these foxes several years ago, but at present one hears of not more than one or two being killed each winter.

20. **Mephitis olida** Boitard. Eastern Skunk.—Skunks are found in sufficient numbers to furnish remunerative employment to the farmer boys who care to employ their spare time during the early winter in hunting them.

21. **Taxidea taxus** (Schreber). American Badger.—Badgers are still quite plentiful in Osceola County. Their presence probably more than anything else accounts for the scarcity of woodchucks. When a badger starts in pursuit of a woodchuck there is no escape for the latter for the badger is by far the better digger. According to local observers, the woodchuck is killed and eaten in a very peculiar manner. After killing his prey, the badger begins to eat at the posterior end, turning the skin back as it proceeds and leaving the skin turned completely inside out when the meal is finished. This was told by different men (Allen, Byam and Roberts), and the writer found a skin of a woodchuck, in exactly the condition described, at the entrance of a burrow which had evidently been raided by a badger. It is said that skunks are destroyed in the same manner.

Badgers have earned the hatred of many people by digging into newly made graves. The writer was told (Stieg) that Mr. Charles Angle a former sexton of a cemetery two miles west of LeRoy had so much trouble with them in this way that he would travel miles to trap one. The writer has seen such burrows in graves but supposed they were merely accidental. From an interview with Mr. Shafer, of LeRoy, it was learned that it is forbidden by law to use poisons in embalming the bodies, and it seems that the weak formalin and the glycerine which are used are not sufficiently distasteful to discourage an animal possessing the appetite of a badger.

They are said, not infrequently, to eat vegetation in summer (Roberts). (Figs. 9 and 18).

22. **Lutreola vison** (Schreber). Northeastern Mink.—The mink is still quite common along the Pine River and its tributaries and about many of the more inaccessible lakes. Several people find remunerative employment trapping them. They are, however, quite rapidly decreasing in numbers.

23. **Putorius noveboracensis** Emmons. New York Weasel.—This little animal is very plentiful in Osceola County but is seldom seen because of the abundance of brush which furnishes hiding places. Many tracks were

seen in the winter of 1911 and '12, but, owing to the early freezing in the fall, trappers caught practically no weasels or mink. It is the opinion of trappers that there are two species, but the writer has seen but this one.

MEASUREMENTS.

Museum Number	Sex	Length	Tail	Foot
41836	male	385	130	45
42185				

24. **Lutra canadensis** (Schreber). Otter.—Otters were observed very often in Rose Lake until the last four or five years (Allen). The writer saw one several years ago. It is believed that the animals have been taken by trappers notwithstanding the closed season for several years. A single otter was seen to capture and devour twelve bullheads in rapid succession at Rose Lake (Allen). One was also recently seen catching rainbow trout in Pine River; the number of fish captured was not noted (Roberts).

25. **Procyon lotor** (Linnaeus). Raccoon.—This species was very plentiful when the hardwood timber was still untouched but was hunted until nearly exterminated. After the timber was cut, the brush became so dense as to make night hunting unpleasant, and now these interesting animals appear to be on the increase again. (Fig. 19.)

26. **Ursus americanus** Pallas. Black Bear.—Black bears are seen in this region almost every summer, when they wander about in search of berries. Where they reside seems to be unknown, altho there are various opinions expressed and various possible places in the waste lands north of Evart, between Avondale and LeRoy, and in the very large swamps south of Cadillac.

27. **Blarina brevicauda** (Say). Short-tailed Shrew.—This shrew is fairly plentiful. It was often observed, and the tracks may be seen very frequently in the snow in early winter.

28. **Condylura cristata** (Linnaeus). Starnosed Mole.—The writer has seen these moles taken from muskrat traps along a small creek in a cedar swamp. An alcoholic specimen in the museum came from Avondale, Osceola County, March 23, 1904.

29. **Scalopus aquaticus machrinus** (Rafinesque). Common Mole.—Very few tunnels of this mole were seen in or near the cultivated lands, altho several places were observed in dry waste pasture lands where their tunnels were very numerous.

THE MOUTH REFLEX OF PHYSA; MAY IT BE SUBSTITUTED FOR THE SALIVARY REFLEX OF PAWLOW IN STUDIES OF THE NERVOUS SYSTEM OF SNAILS.*

ELIZABETH L. THOMPSON.

Although the salivary reflex method as developed by Pawlow has been used quite extensively in the study of animal behavior in Russia and Germany, nothing has been done on it in America. Prof. J. P. Pawlow, Director of the Physiological Department of the Institute of Experimental Medicine in St. Petersburg, devised the method in his work on the relations existing between the physiology of the central nervous system and the psychic reactions of animals, known as animal behavior. Dogs were used in the experiments but the method is applicable to other similar mammals. The method of procedure was briefly as follows. The duct of a salivary gland, preferably a parotid, was opened on the outside through a fistula. Over the opening was cemented a funnel leading into a graduate so that the secretion of the gland could be readily collected and measured. In a later investigation carried on by one of Pawlow's students (Selionyi), a rubber tube was attached to the funnel and this carried the saliva to a tambour and each drop was thus recorded upon a smoked drum.

When the salivary gland is stimulated by food to secrete, the reaction thus produced is termed an "unconditional reflex." When this "unconditional reflex" has been definitely measured by determining the amount of saliva produced, another stimulus such as color or sound is applied simultaneously with the food stimulus. After the association has been established the color or sound is used as a stimulus in the absence of food and a flow of saliva obtained. This is called a "conditional reflex." The glandular secretion being entirely involuntary affords an exact measure of the effect of the stimulus on the nervous system which controls the salivary glands, giving the experiment a physiological as well as a psychological basis.

Pawlow and his students believe that the method can be worked out on only a limited number of mammals. But a similar method is applicable to any organism having a measurable, involuntary muscular action or secretion, definitely effected by external stimulation.

Such a movement was believed by Prof. Reighard to occur in the mouth parts of the fresh water snail Physa, and work is now in progress under his direction. These snails often cling to or crawl upon the under side of the surface film for an indefinite length of time, with the shell below the surface and the ventral side of the body or the foot exposed to view. The mouth, which is on the ventral side, opens and closes frequently a hundred or more times in succession, the reaction probably occurring as the result of stimulation caused by microscopic

*Yerkes and Morgulis: The Method of Pawlow in Animal Psychology. Psychological Bulletin, Vol. VI, No. 8. Aug. 15, 1909.

organisms in the water. It was believed that if the snail were placed in water from which such organisms had been removed—that is, filtered water—and if reactions were induced by the introduction of food into the mouth, any continued reactions after the withdrawal of the food would be involuntary on the part of the snail, and therefore the direct result of applied stimulation. It would thus be an "unconditional reflex."

This method was consequently applied, food being used as the original essential stimulus. The problem resolved itself into an attempt to determine:

(1) The normal reaction of the mouth parts of the fresh water snail, Physa, to a brief application of food as a stimulus.

(2) The reaction of the mouth parts upon the simultaneous application of food and of another stimulus, such as pressure, to some other part of the body.

(3) The reaction of the mouth parts of the snail when the associated stimulus only was applied in the absence of food.

(4) The possible existence of the power of discrimination, by slightly changing the associated stimulus, as for example changing the location of the pressure or applying it to some other part of the body.

(5) The effect of successive stimuli, that is, does the response increase with repetition of the stimulus or the reverse, and do conditional and unconditional stimuli, when repeated, give like results.

(1) The snails for the work were obtained from a local pond. When brought into the laboratory they were in a wild condition, instantly retracting into their shells and dropping to the bottom of the aquarium if touched or jarred in any way. It was therefore necessary to tame them so that they could be readily handled without frightening them. This required a considerable amount of time and careful work, inasmuch as the requirements of the problem depended upon the normal actions or behavior of the animals. More than a hundred of them were placed in an aquarium in which water plants were growing, making the environment as nearly natural as possible. About twenty specimens of approximately the same size were selected for the tests. These were placed in smaller dishes containing water plants and abundance of food and were handled at intervals and mechanically floated upon the surface film until they became so tame that they could be transferred from one dish to another and variously moved about at the will of the operator, apparently without disturbing them.

They were then divided into two groups, the individuals in each being given a distinguishing mark with waterproof paint especially prepared from material which would not injure them. The groups were starved for twenty-four hours and were then tested and allowed to feed for twenty-four hours. A record was made for each individual during a definite number of tests. The individual records show a wide variation, but perhaps no more than might be expected from individuals of any given species of animal. The averages show much less variation than the individual records and give a working basis for the first part of the problem. The actual figures are not given at this time because sources of error have appeared which make check tests advisable.

(2) Pressure, by means of a special apparatus (see fig.1), was in-

troduced simultaneously with the food as an associated or non-essential stimulus, and a record made of the number of reactions occurring after the withdrawal of both, in a given number of tests. The element of disturbance was found to be very great because of the viscidity of the secretion of mucous on the foot and the consequent adhesion of the apparatus. For this reason the mechanical stimulus for a time inhibited the unconditional reflex. This inhibitory effect gradually wore off, however, and the two stimuli combined gave a record showing a smaller number of reactions than normal but averages with no greater variations.

(3) If an association between food and pressure has been established the effect of the association should appear when the non-essential stimulus is employed, that is, for example, when pressure is applied without food. This proved true in 62½% of the cases tried.

(4) and (5) are not yet in a condition to be reported upon.

The actual work has only been fairly started so that the results thus far obtained are not definite enough to justify the formulation of conclusions. The methods employed were suggested by the Pawlow Salivary Reflex Method in Animal Psychology. Pawlow's method commends itself because of its absolute precision although applicable to a limited group of animals. It is believed that work on behavior on any given group of animals might be placed on a similar physiological basis if a measurable reflex could be discovered.

Fig. 1. Apparatus used to introduce food and pressure simultaneously.

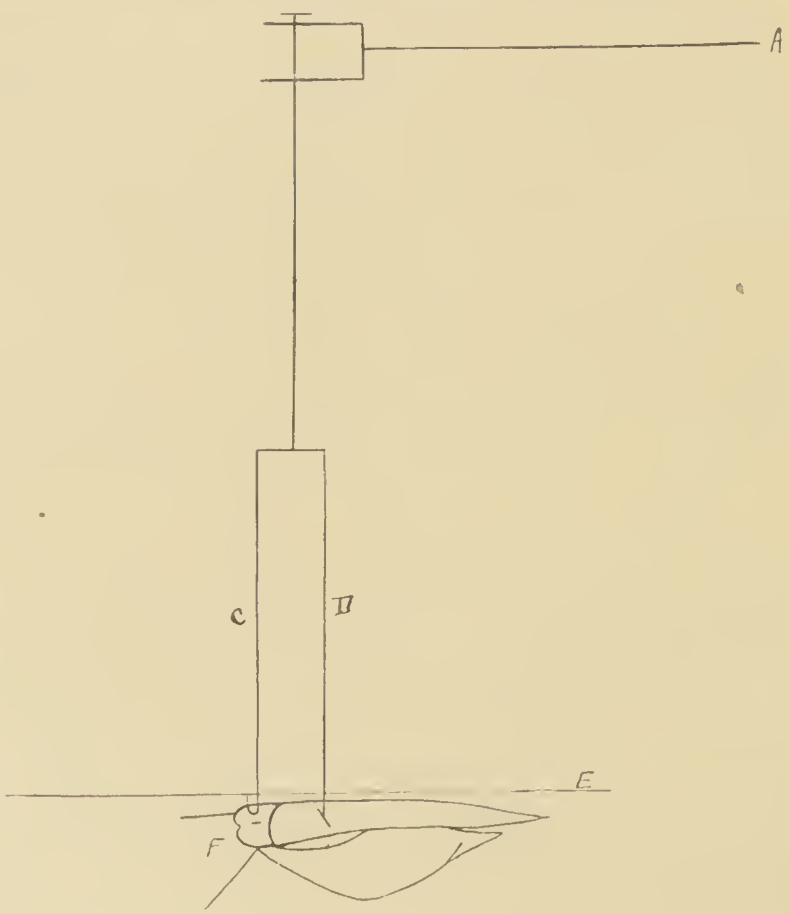


Fig 1

A, handle; B, steel needle; C Food hook; D, pressure bar; E, surface of water; F, snail.

A FEW NOTES ON THE MOLLUSCA OF THE DOUGLAS LAKE REGION.

H. BURRINGTON BAKER.

Last summer, with the assistance of two students (Misses Robertson and Loomis), I made quite an extensive collection of molluscs in the region of the Biological Summer School at Douglas Lake. An attempt was made to study the ecology of the shells of that region, and among the general relationships, to be dealt with in a future paper, there were a few points which appeared to be of especial interest.

During the different oscillations of the level of the Great Lakes after the retreat of the glacial ice, the distribution of the land and water, and the connections between the different smaller lakes and the main lakes in this region, was often very different from at present. From the adjoining map (Plate —) of the northern portion of the southern peninsula of Michigan, it will be seen that, at the time of the highest Lake Algonquin Beach, the northern limit of the mainland was south of Burt Lake; and that the remainder of the peninsula was flooded, with the exception of a large island north of the present site of Petoskey and nine small islands to the east of this largest one. At this time, then, Douglas and Burt Lakes were simply deeper portions of the channels between these islands, and were directly connected with the Great Lakes. Later, the ice melted back so that the Ottawa outlet drained the water down to below the level of the present Lake Huron; but, with the upward tilting of the land in the northern portion, the water returned to the highest Nipissing level so that a channel thru the beds of the present Mullet, Burt, and Crooked Lakes separated a large island enclosing Douglas Lake.[1]

At present, as was probably also true at the time of the Nipissing Great Lakes, Douglas Lake is connected with Burt Lake by Maple river, a small creek flowing thru many tamarack swamps. This creek has too soft and mucky a bottom to allow the free migration of *Goniobasis livescens* (Menke), a shell very abundant in Burt Lake and the Straits of Mackinac, and it is not found in Douglas Lake altho there are many places in that lake that appear to be equally favorable to it. This, it appears to me, is pretty good proof that this shell was not present in the glacial Lake Algonquin but is a later immigrant from the south.

The other prominent shells of these lakes are shown in the following diagram:

STRAITS OF MACKINAC.

L. emarginata Say, and approaching var. *canadensis* (Sowerby).
Physa ancillaria magnalacustris Walker.

[1] "Outline of The History of the Great Lakes," Frank Leverett. 12th Rept. Mich. Academy of Science, 1910; pp. 35-39.

Planorbis bicarinatus Say, and approaching var. *aroostookensis* Pilsbry.

Planorbis campanulatus Say?

Campeloma decisum (Say).

Sphaerium acuminatum (Prime).

NORTH END OF BURT LAKE.

Lymnaea stagnalis perampla Wkr.

L. emarginata Say, var.

P. ancillaria parkeri (Currier).

P. bicarinatus Say.

P. campanulatus Say?

C. decisum (Say).

S. acuminatum (Prime).

DOUGLAS LAKE.

L. stagnalis perampla Walker.

L. emarginata angulata (Sowerby).

P. ancillaria parkeri.

P. bicarinatus portagensis Baker and *P. bicarinatus percarinatus* Walker.

Planorbis campanulatus smithii Baker.

C. decisum (Say).

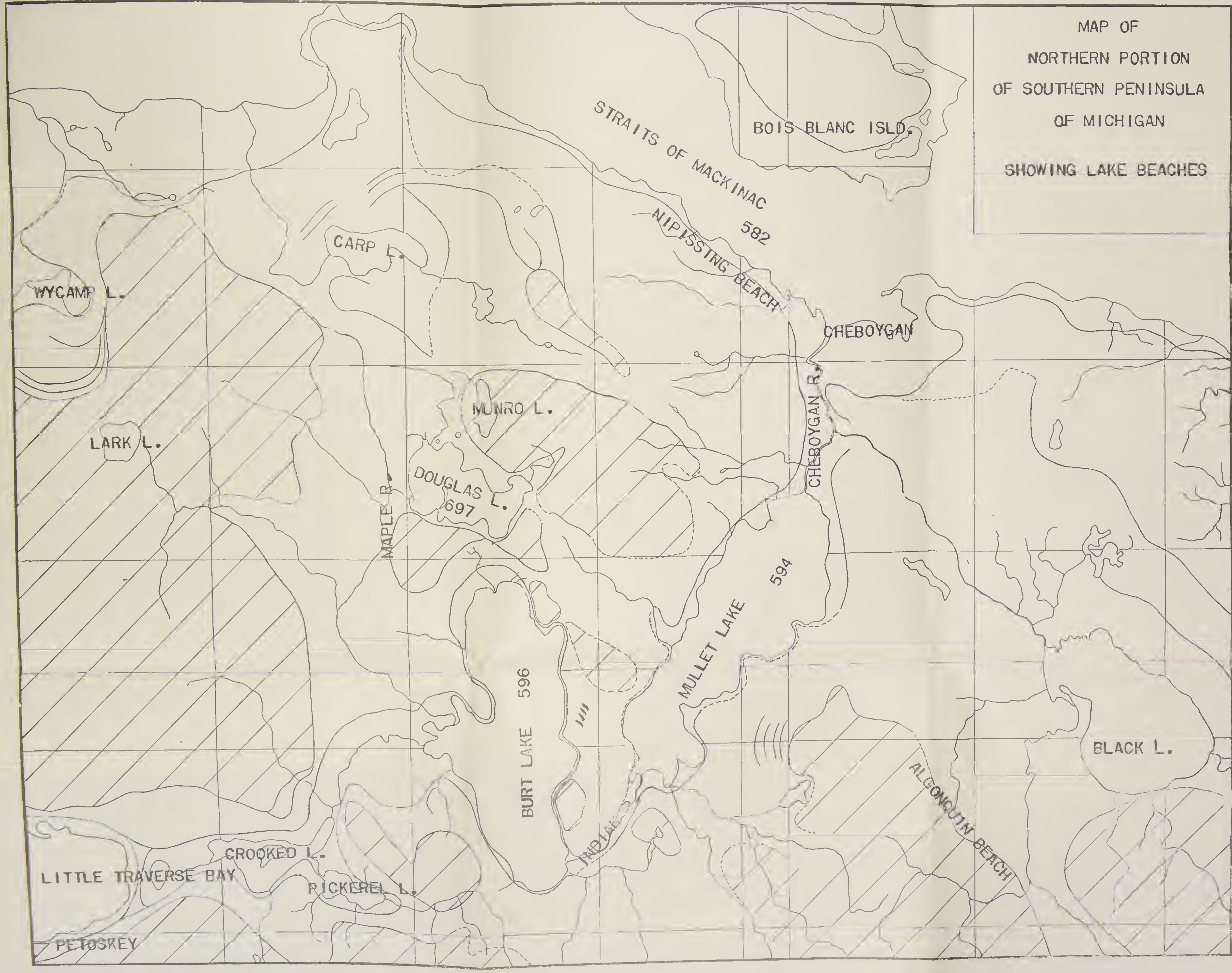
S. acuminatum (Prime).

S. sulcatum (Lam.).

It will be seen from this that all of these other shells in the Straits of Mackinac and Burt Lake are also represented, at least by varities, in Douglas Lake, but this is not proof that they arrived during the time of Lake Algonquin as *Campeloma decisum* (Say); *Sphaerium sulcatum* (Lam.), are also found in the Maple River, and the other forms have shown their ability to migrate up similar streams, as at Higgins and Houghton Lakes.

The pulmonates from Douglas Lake which are given in the above list, appear to be all deep water forms, and have apparently become adapted to breathe water instead of air. They come up into shallow water to breed and lay their eggs at certain times of the year. According to the data on hand, *Lymnaea stagnalis perampla* Walker seems to prefer to lay its eggs on weeds, especially in the mouths of the streams, and in the summer of 1911 came up during July; *Physa ancillaria parkeri* (Currier), on protected, marly sand shoals in very shallow water during the early spring; *Planorbis bicarinatus portagensis* Baker and probably *P. bicarinatus percarinatus* Walker in similar places in slightly deeper water at a later time; *Lymnaea emarginata angulata* (Sowerby) in the same place as *Physa* only in the later part of July; and *Planorbis campanulatus smithii* Baker in mucky-bottomed shoals during the late summer. The writer hopes to obtain more data along this line next summer and the above results are purely tentative.

These shells appear to have been forced into deep water on account of the fact that most of the shore of Douglas Lake is of fine, shifting



MAP OF
NORTHERN PORTION
OF SOUTHERN PENINSULA
OF MICHIGAN
SHOWING LAKE BEACHES
STRAITS OF MACKINAC
582
BOIS BLANC ISLD.
NIPISSING BEACH
CHEBOYGAN
CHEBOYGAN R.
CARP L.
WYCAMP L.
MUNRO L.
LARK L.
DOUGLAS L.
697
MAPLE R.
MULLET LAKE
594
BURT LAKE
596
BLACK L.
ALGONQUIN BEACH
INDIAN
CROOKED L.
LITTLE TRAVERSE BAY
PICKEREL L.
PETOSKEY

sand which would make it very difficult for these species to live and feed in shallow water. These varieties appear to be purely the effect of the environment on the parent species as in the outlet of Douglas Lake into Maple river there were found adult *Physa ancillaria parkeri* (Currier) that had apparently migrated in to breed, juvenile specimens of the same species that could not be distinguished from those in the very shallow water on the shoals of the lake itself, and larger shells, connected with the juvenile ones by those of intermediate size, which were even narrower than typical *Physa ancillaria* Say!! One of these latter measured: altitude 12 mm., diameter 6.1 mm., length of aperture 8.8 mm., while a young specimen of the form *parkeri* (Currier) from the lake measured: 12.3 mm., 9.2 mm., 10.5 mm. I think it probable that this narrow form had been produced from the deep water form by the action of the conditions of the creek during a single generation. Similar but not so striking relations seemed to hold for *Lymnaea stagnalis perampla* Walker and *L. stagnalis appressa* (Say), the typical river form in this region; *Planorbis bicarinatus portagensis* Baker and typical *P. bicarinatus* Say; and perhaps also *Lymnaea emarginata angulata* (Sowerby) and a form of *Lymnaea emarginata* similar to that in Burt Lake. It almost appears that these shells may be compared in a crude manner with different kinds of liquids, which, when poured into differently shaped moulds (their environment), assume different shapes.

Plate —. Map of northern end of Southern Peninsula of Michigan showing beaches of glacial Lakes Algonquin and Nipissing.[2]

The cross-hatched portions show what was land during the time of the Algonquin highest beach level; the highest Nipissing beach is represented by the line just inside the present lake shore and surrounding Mullet, Burt and Crooked Lakes. The figures in the different lakes are their approximate hights above sea-level. The large squares represent the townships, or areas six miles square.

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[2]The data for this map was taken from the large map accompanying the paper by A. C. Lane: "Summary of the Surface Geology of Michigan," Rept. of the State Board of the Geol. Surv. of Mich. for the Yr. 1907; from the paper by F. Leverett mentioned above; and from corrections kindly made by Mr. Leverett from his field notes.

THE ORIGIN OF THE GERM CELLS IN THE TOADFISH. (OPSANUS TAU.)[1]

BY EMORY W. SINK.

The following is a preliminary account of the problem of the Early History of the Germ Cells in Teleost Fishes.[2] This subject in general is one to which considerable attention has been given by a score of workers in recent years. It is of interest not only because of its bearing on morphological development but especially because of its relation to problems of heredity. Whether or not the germinal material is handed down from one generation to the next in an unchanged condition, or whether the germ plasm ever arises from somatic cells of the embryo, is a question which is fundamental in its bearings on genetics.

The Invertabrates have been a very favorable group for this study and considerable work has been done on them with interesting results. The Vertebrates likewise have been employed for similar investigations, but for various reasons the problem has been more complex, so that the results are not as far reaching as those from a study of the Invertebrates.

The fact that the germ cells are found in various parts of the Vertebrate embryo during development and that they actively migrate or are passively carried to a definite region of the embryo where the sex glands form, is a phase of the problem so complex that many theories have been advanced to account for the process.

Three views have been held in regard to the origin of the germ cells in Vertebrates. The first known as the Germinal Epithelial Theory was advanced by Waldeyer in 1870. This investigator maintained that the germ cells arose from epithelial cells in the region (germinal ridge) of the embryo where the future sex glands formed. This view was plausible at the time and quickly accepted by many embryologists, for it was in this ridge that the germ cells could first be distinguished. The fact that they are so conspicuous in this region, led many observers to think that they originated there, but the method of this origin has not as yet been satisfactorily explained.

The second view proposed by Rückert and Van Wijhe in 1888-9 maintains that the germ cells originate from a definite portion of the segmental mesoblast and are later transported during development to the germinal ridge. This view has been subjected to much speculation but is not accepted by most workers of the present decade.

The third view, which is probably the correct one, is based not entirely on observation, but also on the assumption that the germ cells are set aside or segregated from the somatic cells at a very early stage of

[1]The work on this investigation was carried on in the Zoological Laboratory of the University of Michigan under the supervision of Prof. Jacob E. Reighard.

[2]For a good resume of the recent work on this subject, reference may be made to Gideon S. Dodd's paper on the "Segregation of the Germ-Cells of the Teleost, Lophius." Journal of Morphology, Vol. 21, No. 1.

development and remain in a more or less primitive condition for some time. They then migrate by self active amoeboid movements or by a passive displacement due to the shifting and readjustment of embryonic tissues during development to the definitive position in the sex glands. This view is supported by many investigators who have succeeded in tracing their origin to embryos in blastoderm stages, but who have not as yet determined their origin because of the difficulty in distinguishing the germ cells from somatic cells in still earlier stages. It seems probable however, that they are really present in these earlier stages although no methods have yet been discovered by means of which they can be recognized.

The material upon which the present investigation is based, consists of embryos of the toadfish, *Opsanus tau*, a marine Teleost belonging to the family Batrachidae. This species occurs abundantly along our eastern coast, and because of its peculiar habit of nesting in such receptacles as tin cans and rubber boots, and also under stones and boards, has been a subject of much interest and study. The eggs after being laid adhere to the inside surface of the receptable or on the under surface of the stone or board and remain attached until the young are about three-fourths of an inch in length. The fry then break loose from the adhesive disc and escape thru a rupture of the egg capsule into the outside world.*

While at the Marine Biological Station, Woods Hole, Mass., during the summer of 1911, a complete series of embryonic stages of the toadfish was obtained. The material was fixed in various solutions including Bouin's picro-formol, Tellyesnicky's and Zenker's fluids. These fixatives proved satisfactory but the great amount of yolk present in this egg became so hard that it was necessary to remove the blastoderm before sectioning the embryo. Serial parafin sections six microns in thickness were cut transversely and longitudinally and stained in most cases with two percent acid haemalaun and counterstained with Orange G. or eosin. The series were studied beginning with the oldest embryos and then proceeding in succession to younger stages.

In embryo number 105Ab, which measures 8.6 mm. in length, and still retains a large yolk sac, most of the germ cells occupy their definitive position in the sex glands. These glands extend as longitudinal ridges or evaginations of mesothelial tissue projecting into the body cavity one on either side of the dorsal mesentery of the alimentary canal. The germ cells are easily seen in sections and are distinguished by their large size, circular outline, and well defined nucleus and nucleolus. The above characteristics have been the main features for recognizing the germ cells in early stages of both Vertebrates and Invertebrates.

No attempt has been made as yet to count the number of germ cells in the toadfish, but it was noticed that they are about evenly distributed between the two sex glands.

Figure I is from a microphotograph of a portion of a cross-section of embyro 105Ab thru the region of the sex glands.

Figure 2 shows a small portion of Fig. 1 more highly magnified.

*For fuller description of the habits of the toadfish, refer to E. W. Gudger's account on the "Habts and Life History of the Toadfish (Opsanus tau)." Bulletin Bureau of Fisheries, Vol. 28, 1908.

The two small peninsular projections, (Fig I d), into the body cavity (g) are the sex glands. In each is a germ cell (Fig. 2 f), showing the characteristics mentioned above.

Figure 3 is from a sagittal section thru the sex gland of an embryo (93Aa) in a stage similar to that of embryo 105 Ab (Figs. I, 2). Numerous germ cells are present in the sex gland (d).

Figure 4 is from a sagittal section thru the sex gland region of embryo 105Aa which is somewhat younger than embryo 105Ab. Germ cells (f) are shown in the sex gland.

Figure 5 shows a small portion of the embryo 105Ac including a sex gland in which a germ cell (f) is present at the neck of the sex gland (d).

In embyro 90Aa which measures 4.75 mm. in length, the sex glands have not yet formed. In this stage the germ cells occur in the germinal ridge which later produces the sex glands. Figures 6 and 7 indicate the position of the germ cells (f) in the ridge just ventral to the Wolfian duct (Fig. 6, c). It was stages of this type which gave to Waldeyer and others the foundation for the Germinal Epithelial Theory. Figure 7 also shows germ cells (f) in the neck region of the gut wall.

Figures 8, 9 and 10 are from embyro 84Ba which measures 3.5 mm. in length. In this stage only a few germ cells are found in the germinal ridge. Many are found in the gut entoderm in the process of mitosis. Others are found in positions ranging from that in the gut entoderm to that in the germinal ridge. Figure 8 shows one germ cell (f) in the splanchnic layer of the gut just ventral and to the left of the neck region of the gut mesentery. Figure 9 shows one germ cell (f) in the resting condition within the gut entoderm. Figure 10 represents a section thru the hind gut region showing at the dorsal portion of the gut two germ cells (f) in the process of division. In the same figure in the left wall of the gut is a germ cell (f) which shows a peculiar bilobed nucleus. This condition of the nucleus has been referred to by other investigators. Only a few cells with this feature were found in the study of the sections. The reason why more are not observed is probably due to the fact that only a small number happen to be cut in such a plane as to show this peculiarity.

It is impossible at the present time to report definitely the discovery of germ cells in a stage earlier than that shown in Figs. 9 and 10 and described above. In one embyro 19Da thus far studied which is considerable younger, cells which may be germ cells were observed near the region of the primary entoderm where the gut is destined to form. More sections of embryos intermediate in age between 84Ba and 19Da are necessary to determine the validness of the above probability.

Figure II is a cross-section of this embryo 19Da thru the posterior region. No germ cells are represented but the section is interesting because of the large periblast nuclei (n) which are seen in the lower part of the figure. These nuclei are represented here because so little is certain in regard to their functions and future fate. These nuclei are believed to arise from the marginal cells of the germ disc at a stage during gastrulation. Their function is probably a physiological one. They are supposed to work over the yolk in such a way that it can be more readily absorbed. In many instances, a yolk granule (Fig. 12o), is present at close proximity to such a periblast nucleus Fig. 12, n). Although

the fate of these periblast nuclei is somewhat unsettled it is quite commonly agreed that they do not aid in the formation of any structure of the embryo.* The possibility suggests itself however that these periblast nuclei because of their large size, apparently primitive condition and the possession of yolk globules may really be the undifferentiated blastomeres, some of which may become the centers of the primordial germ cells (the origin of germ cells directly from blastomeres is common among invertebrates).

Embryos in stages between those shown in Figs. 10 and 11 are being studied in an effort to determine the fate of some of these nuclei and the earlier history of the germ cells.

May 1st, 1912.

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*See H. F. Ziegler's Lehrbuch der vergleichenden Entwickelungegeschichte der niederen Wirbeltiere. Jena, 1902. Verlag von Gustav Fischer. Pages 172-178.

EXPLANATIONS OF FIGURES.

(Abbreviations used.)

a—nerve cord.
b—notochord.
c—Wolfian duct.
d—sex gland.
e—alimentary canal (gut).
f—germ cell.
g—body cavity.
h—aorta.
i—opening due to shrinkage.
j—ectoderm.
k—mesoderm.
l—entoderm.
m—periblast layer.
n—periblast nuclei.
o—yolk granule.

Figures 1-12 are from microphotographs made by the author, illustrating the successive positions of the germ cells from the sex glands to the lateral and dorsal wall of the gut entoderm.

Figure 1. Portion of a cross section of embryo 105Ab thrue the sex glands (d). Length of embryo 8.6 mm.

Figure 2. Portion of Fig. 1 more highly magnified, showing a germ cell (f) in the sex gland.

Figure 3. Portion of a longitudinal section of embryo 93Aa thru the sex gland (d), showing several germ cells (f). Length of embryo 5.75 mm.

Figure 4. Portion of a longitudinal section of embryo 105Aa showing germ cells (f) in the sex gland. Length of embryo 8.4 mm.

Figure 5. Portion of a cross section of embryo 105Ac thru the sex gland (d), showing a germ cell (f) at the neck of the gland. Length of embryo 8.6 mm.

Figure 6. Portion of a cross section of embryo 90Aa thru a region showing a germ cell (f) in the germinal ridge just ventral to the Wolfian duct (c). Length of embryo 4.75 mm.

Figure 7. Portion of a cross section of embryo 90Aa, showing germ cells (f) in the germinál ridge and also in the mesentery supporting the ailmentary canal (e).

Figure 8. Portion of a crosss section of embryo 84Ba showing a germ cell (f) in the mesotherium just dorsel and to the left of the gut entoderm (e). Length of embryo 3.5 mm.

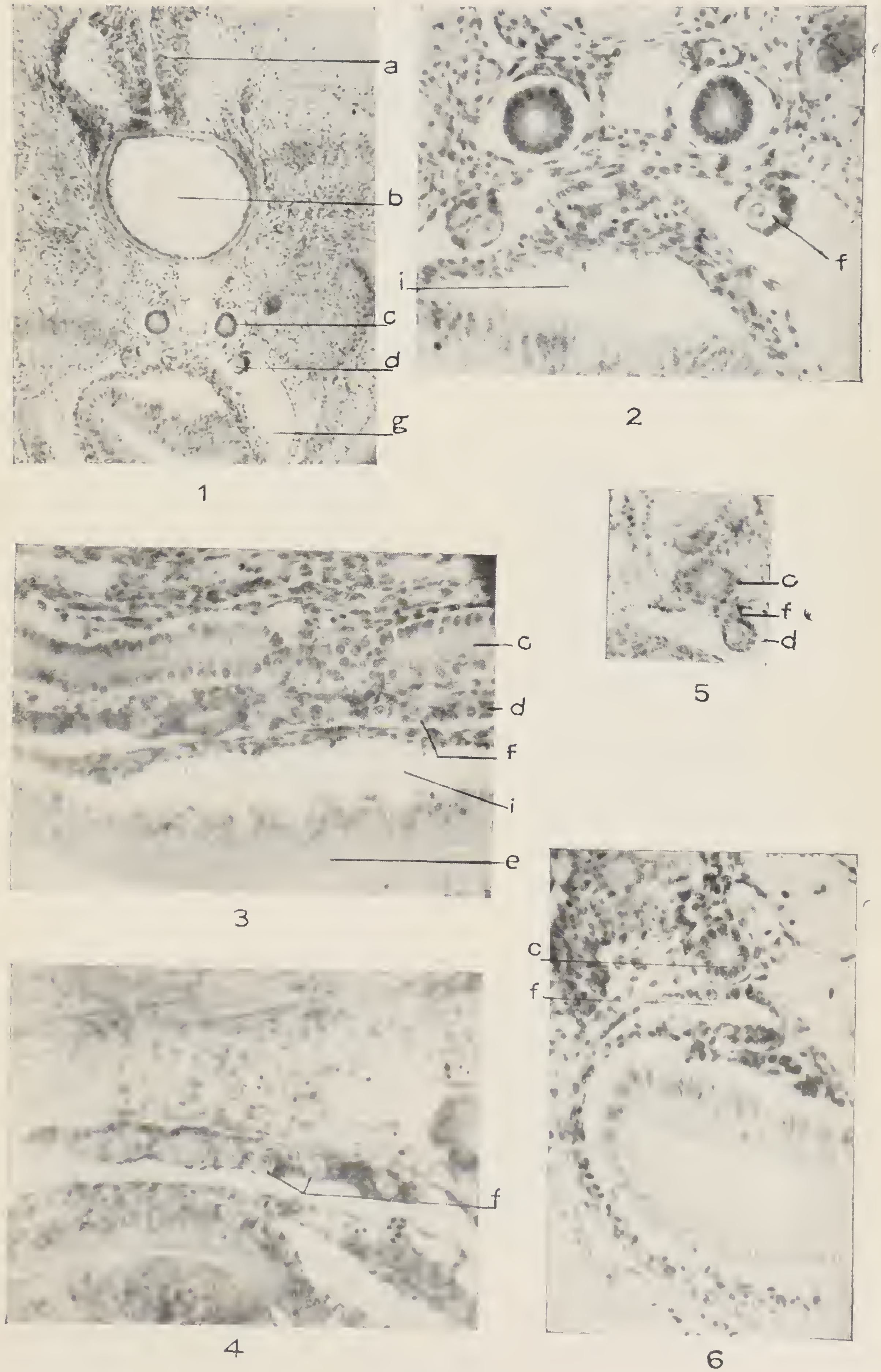
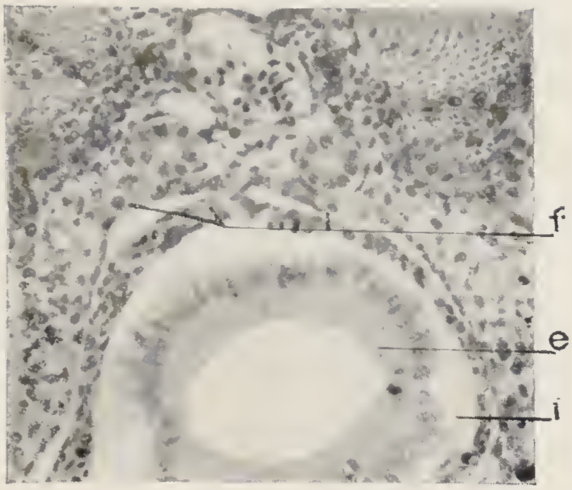


PLATE I.



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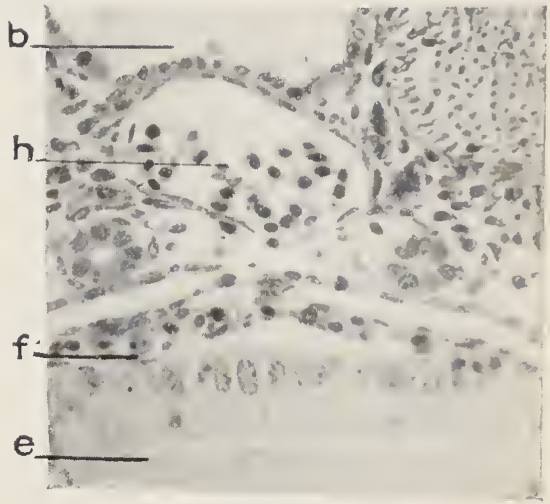

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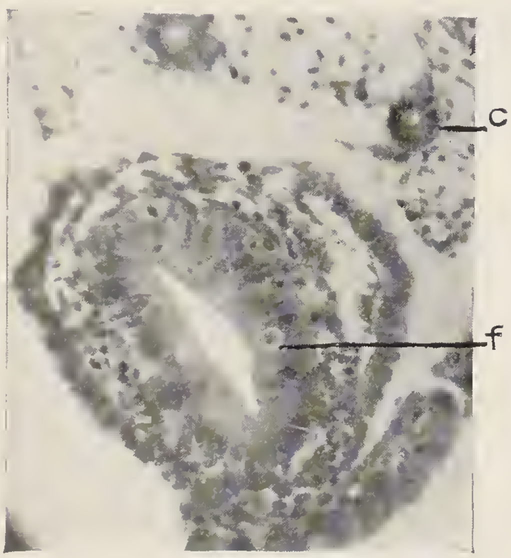

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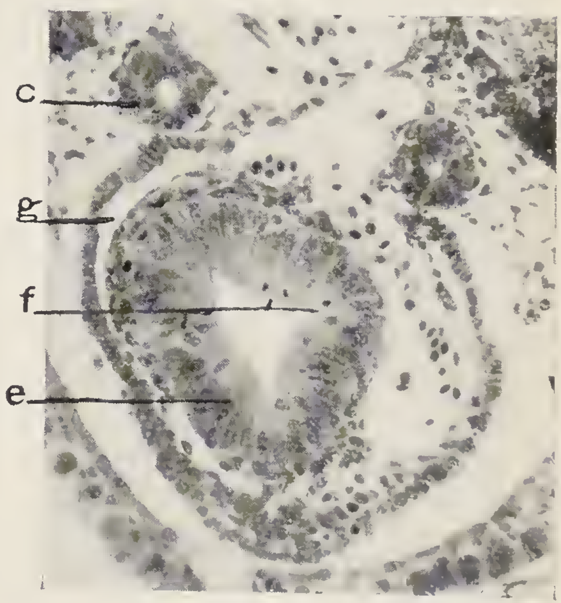

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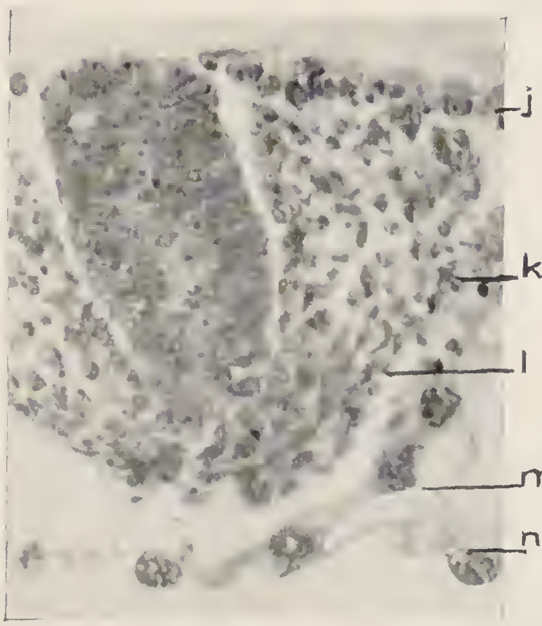

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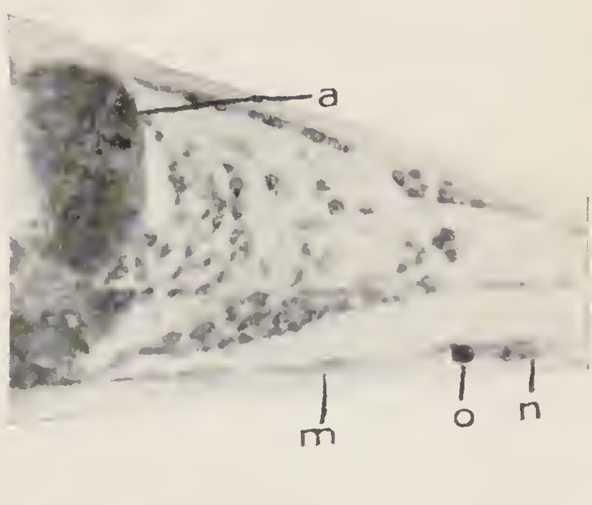

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PLATE II.

Figure 9. Portion of a cross section of the same embryo 84Ba showing a germ cell (f) within the gut entoderm.

Figure 10. Portion of a cross section of the same embryo thru the region of the hind gut showing three germ cells (f) in the gut entoderm two of which are undergoing mitotic division, and the other possessing a peculiar bilobed nucleus.

Figure 11. Portion of a cross section of embryo 19Da showing several periblast nuclei (n) in the periblast layer (m).

Figure 12. Portion of a cross section of the same embryo showing a yolk granule (o) in close proximity to a periblast nucleus (n).

ON CERTAIN RELATIONS OF THE FLORA AND VERTEBRATE FAUNA OF GRATIOT COUNTY, MICHIGAN, WITH AN APPENDED LIST OF MAMMALS AND AMPHIBIANS.

H. M. McCurdy.

As there are so few reported records bearing upon the question of the distribution of the biota for the interior of the State of Michigan, the following notes and records are presented. These records are necessarily incomplete and additions will in time be made. It is believed, however, that they are of sufficient importance to direct attention to other areas in the interior and to modify to some extent the views generally held concerning the relations existing between the interior and the border regions.

In the literature on the geographic distribution of plants within the limits of the State, the differences are generally emphasized and have been in advance of the evidence. One is strongly and unduly impressed with the idea that the flora is decidedly more southern along the coasts especially the west than in the interior at a given latitude. Ruthven[1] while expressing this view, states that he does not find so great difference on the east side of the State as appears to hold for the west side. For the regions of Sand point, Roscommon and Crawford counties and Manistee, Coons[2] states that the vegetation has advanced in a V-shaped manner the central portion of the state lagging behind the border portion. "Of the eight species named by Coons, three. (Asimina triloba, Gleditsia triacanthos, and Cercis canadensis) have not been reported north of that. The remaining species occur in the interior, in the latitude of Saginaw Bay. A more detailed study will doubtless reveal their presence still farther toward the north. The others mentioned are: Benzoin aestivale, Sassafras variifolium, Liriodendron tulipifera (rare), and Celastrus scandens. It must be remembered that our knowledge has advanced northward

[1]Ruthven, Alexander G. et al. A Biological Survey of the Sand Dune Region on the South Shore of Saginaw Bay, Michigan, Mich. Geol. and Biol. Survey Pub. 4 Ser. 2 (1911).

[2]Coons, G. H. Sec. 1, p. 59.

along the shores and the interior is little known. As our knowledge increases the supposed differences grow less. But it is not to be expected that all differences will eventually disappear. For the region north of Saginaw Bay, Beal[3] gives northern plants found on the east (Harrisville) and not on the west side (near Frankfort) and certain Southern plants found on the west not found on the east side. Practically all in both lists are found in the interior, south of the latitude of Saginaw Bay. Other species named later give additional evidence tending to diminish the supposed differences.

This indicates that when particular species are considered, disregarding their frequency, the differences between the interior and the coastal regions are not so great as they are generally thought to be. The limits of distribution northward and southward of particular species are not sharply defined. Particularly is this true in a region of varied soil and surface features. Until much more detailed study is made of other areas in the interior it is impossible to state to what extent the vegetation and animal life of the interior differ from that of the coast at a given latitude. The latitude just south of Saginaw Bay and Alma have practically the same average temperature. Cooper's[4] temperature records for the vicinity of Bay City, Saginaw, and Saginaw Bay indicates that there are local differences which appear to be chiefly confined to points near the shore. A comparison in the points farther inland shows very little influence so far as averages indicate. This is further borne out by the fact that in the fauna and flora essentially the same species are found. Such differences as exist are yet to be made out. Undoubtedly other factors play a very important part, and at times they are the deciding factors. Perhaps the most important are; adaptations and opportunities for distribution, physiographic and edaphic conditions and competition and association. Coon's (See 1 loc cit) has shown that these are important factors in the habitats in the sand dune region on the south shore of Saginaw Bay, and Livingston[5] has found similar relations between habitat and vegetation to exist in Roscommon and Crawford counties and also in Kent county. This will be seen to be true for habitats in the central part of the State if the Alma area is at all representative.

It is thus seen that in both the coastal regions and in the interior, the differences between local habitats are greater than the climatic differences between the respective regions. If this be true, the biota of the interior and the border areas would differ from each other with the relative extent of the various types of habitats.

The Alma Area,[6] which is the north half of Gratiot county, includes the geographical center of the lower peninsula of Michigan, and the physical features and climate may be regarded as typical of the central portion of the State. It must be remembered however that local conditions vary somewhat in different localities. The area therefore is important from the standpoint of distribution. In this Soil Survey[5] a brief description of the area is given and is sufficient for the present.

[3]Beal, W. J. Michigan Flora, Fifth Ann. Rept. Mich. Acad. Sci., 1903, p 20.
[4]Cooper, W. F. Geology of Bay County, Mich. Geol. Survey, 1905, pp. 356-358.
[5]Livingston, B. E. Relation of Soils to Natural Vegetation in Roscommon and Crawford Counties, Michigan. Ann. Rept. Mich. Geol. Survey, 1903, 9-30. The Distribution of the Upland Plant Societies of Kent County, Michigan, Bot. Gaz., 35: 36-55. Map.
[6]Hearn, W. Edward and Griffin, A. M. Soil Survey of the Alma Area, Mich. U. S. Dept. Agri. Bureau of Soils. Advance sheets, Field operations, 1904.

There is considerable variation from that account in certain respects, but these may be omitted from this discussion. To the east of a line passing north and south near St. Louis and Ithaca the surface is level, the soil consisting of water laid material or lacustrine deposits, with but little interruption. West of this line, the surface is marked by low moraines extending north and south. The moraines are low on the east and increase in elevation toward the west side of the area. These moraines vary in the character of their materials, some being covered by clay, others consisting entirely of sand and some gravel. The depressions according to depth and extent contain well drained soils, muck and peat deposits and some marl deposits indicating the presence of former lakes, and in some of the depressions are still to be found extensive swamps, bogs and lakes. Half Moon Lake lying near the northwest corner of the area is the largest lake lying within the area. It is now about a mile long by one-half mile wide and has suffered great reduction by filling with vegetation. The most interesting part of the area from a biological standpoint is a strip along the west side including Half Moon Lake and the moraines to the south. Pine River enters the area a few miles southwest of this lake and follows a depression southward between the moraines to a point near the southwest corner where it turns northeastward across the area. Thus the western part has the most varied conditions to be found in the region.

Aside from the brief mention in the Soil Survey there are no published records referring directly to the plant life of this section. It is not possible at this time, nor is it necessary to give a complete list of the plants known to be found here. Only those species which have particular interest as more southern or northern forms are mentioned, and the list does not represent a complete catalog of such forms. It is given to illustrate the conditions which a more detailed study would more fully reveal.

Omitting the modern beach and dune formations the habitats and associations are comparable to those of the coast. The Mesophyte Forest type prevails over the larger part of the area. This includes level well-drained soils, the low moraines and over-wash plains. The fossil beaches of early glacial lakes are nearly obliterated, appearing only in certain localities on the western border of the lake plains. Through increased drainage the Helophyte formations formerly of considerable extent have become largely transformed toward Mesophyte conditions. In the western portion where the physiographic conditions are more varied, the associations are those usually found from fresh water lakes and reed-brush and wooded swamps, to Mesophyte Forest and sand ridges and clay ridges. Any further characterization setting forth the details of these as compared with corresponding formations elsewhere is dependent upon a more detailed study.

Northern forms that are found on or adjacent to the area and occur more rarely farther southward are: Abies balsamea, Taxus canadensis, Picea Mariana, Picea abies, Pinus resinosa, Tsuga canadensis (spreading if permitted) Thuja occidentalis, Clintonia borealis, Myrica asplenifolium, (rare) Selaginella apus, Epigea repens (occurs westward) Gaultheria procumbens, Cornus canadensis, Arethusa bulbosa, Kalmia polyfolia, chamaedaphne calyculata, Chiogenes hispidula, Andromeda

glaucophylla, Eriophorum callitrix, Dracocephalum parviflorum, Lonicera oblogifolia, Ceanothus ovatus, etc. Some of the bog forms occur in a bog adjacent to the area on the west and they possess no great significance.

Most of the more northern forms of animals have been earlier driven from this section. There may be mentioned Sciurus carolinensis leucotis, (melanistic variety), sciurus hudsonius loquax, still fairly common; sciuropterus sabrinus macrotus and Lepus americanus. The latter is occasionally taken. The southern flying squirrel is more commonly found.

Some of the southern forms whose distribution in the interior are of interest are mentioned below. Some of these are known to occur farther north in the interior, and others will doubtless be found to do so. Some of them have been pointed out by other writers as illustrating the northward movement of forms along the borders of the State. The list includes such forms as:

Adiantum pedatum (common), Carya macrocarpa, Carya ovata, Juglans cinerea (said to have been abundant formerly), Juglans nigra, Liriodendron tulipifera (rare), celastrus scandens, Sassafras variifolium Bezoin aestivale.

Blue tailed skink (Eumeces quinquelineatus Linneaus), Storeria dekayi Holbrook, Leopeltis vernalis DeKay, Lampropeltis doliatus triangularis Boie, Chorophilus nnigritus triseratus Wied, Necturus maculosus Refinesque, Diadelphis virginiana.

It is seen that the area is rich in its types of vegetation. All forms of general occurrence in the state are present together with a notable proportion of northern and southern forms. The differences between the coastal regions and the interior at this latitude are certainly much less than the literature on the subject would lead one to expect. This question however must depend upon a closer study of all the factors involved.

The following list of Mammals represents some interesting transitional features. As the area under consideration lies in the center of the lower peninsula and extends from the plains of the Grand-Saginaw valley and the early glacial lakes on the south and east to the clay and sand moraines of the interlobate region of the Michigan and Saginaw lobes on the west one may expect to find some relation between these physical and historical features on the one hand and the fauna and flora on the other. It serves to give the region a biota representative of both the northern and southern types and also some intermediate stages. The flying squirrels may be mentioned in this connection, and the retreat of some of the northern forms to points farther north, for example, the varying hare and other species which left the area earlier. The area must also represent or lie near the northernmost limit of distribution of the American Opossum. A number of the smaller mammals not given here undoubtedly occur, but as no good records for them have been obtained they are left for verification.

LIST OF MAMMALS.

1. Diadelphus virginianus Kerr, Opossum. This is included on the following evidence. A Mr. Hufford in 1900, killed an opossum on his farm near Breckenridge. He had at that time recently come from Ohio and knew the animal well. Mr. Marcus Polasky a fur dealer in Alma bought an opossum skin from a farmer of Lake View in Montcalm county in 1910. His sales record is also evidence. If this is accepted as good evidence this extends the range for the opossum in the state.

2. Cervus canadensis Erxleben, American Elk. This is said to have been present in the early history of the central part of the State. The direct evidence offered is the larger part of a horn found near here and now in the Hood Museum.

3. Odocoileus americanus borealis Erxleben, Northern white tailed deer. This is said to have been abundant in the early settlement of the county. It became scarce about twenty-five to thirty-five years ago. The latest record for this species was in 1908 when one was killed in the northeastern part of this County. It had apparently been driven into the area by fires prevalent at that time in regions to the north.

4. Sciurus carolinensis leucotis Gapper. Northern Gray Squirrel. Both the gray and the black forms were formerly abundant. The gray is still fairly abundant and the black form is rare. The museum specimens were taken near Alma.

5. Sciurus niger rufiventer Goeffroy. Fox Squirrel. Mr. Robert Wilson, a student, brought a specimen of this to the writer, Nov. 29th, 1910. He took the specimen in a woods one mile south of Alma. The museum specimens were taken near Alma.

6. Sciurus hudsonicus loquax, Bangs. Red Squirrel. This squirrel is not uncommon. The writer took a specimen November, 17th, 1910. There are four specimens in the Hood Museum all taken in this locality.

7. Tamias striatus lysteri Richardson. Lyster's Chipmunk. This species is common wherever favorable conditions afford it protection. A pair housed themselves under an old board walk in the Campus near the administration building. Two nearly grown individuals made their way into the building on more than one occasion.

8. Citellus tridecemlineatus Mitchell. Striped spermophyle. Striped Gopher. The writer has not taken this species but it is said to have been taken in the southwest part of the area. If it occurs within the limits of the area it would be expected to be found in the western part. One specimen is in the Stillwell Collection in the Hood Museum.

9. Marmota monax Linnaeus. Woodchucks are rather common in the clay and sandy soils and are occasionally invading the fields with their burrows. A specimen was brought to the writer in March, 1911, from the Windsor Farm one mile north of Alma.

10. Sciuropterus volans volans, Linnaeus. Southern Flying Squirrel. A specimen was taken by a Mr. Bradford three miles southwest of Alma, in 1910. Other specimens are in the Stillwell collection in the Hood Museum all of which were taken near Alma.

11. Sciuropterus sabrinus macrotus Mearns. Canadian Flying Squirrel. One specimen in the Stillwell collection possesses characteristics somewhat intermediate, but if the coloring of the ventral surface is considered with the other features, it should be macrotis. This species is reported from Montcalm County.

12. Castor canadensis Kuhl. Canada Beaver. The beaver were early driven from this section probably over fifty years ago. There are remains of their dams at several points in the county.

13. Musmusculus Linnaeus. House Mouse. This species is all too common. Not infrequently specimens are taken having some white beneath and a narrow line of white extending from the forehead downward between the eyes nearly to the tip of the nose.

14. Mus norwegicus Erxleben. Common or Norway Rat. This species has been seen in great numbers living in a dump heap near the dam in Pine River at Alma. Such accumulations of rubbish and refuse are the chief centers from which these animals spread to do their damage.

15. Peromyscus leucopus noveboracensis Fisher. Northern white-footed Deer Mouse. This species is common though apparently not so abundant as reported by Wenzel for Douglas Lake.

16. Peromyscus maniculatus bairdi. Hoy and Kennicutt. Prairie White-footed Mouse. Michigan Mouse. The specimen referable to this species was taken from a rubbish heap in a back lot in April, 1911, 710 State Street Alma. Its characteristics are typical as described by Osgood[6] and Hahn[7]. Hahn states that he had not obtained this species except in thick grass with which this record essentially agrees.

17. Microtus pennsylvanicus Ord. Meadow Mouse. The Meadow Mouse is very abundant in favorite situations. Their runways thread the low meadows in every direction beneath the snow and dead grass in winter. The writer has seen the Pennsylvania vole take leaves from the wild lettuce in preference to grass blades, probably on account of the former being more tender at the time.

18. Fiber zibethicus Linnaeus. Muskrat. This "versatile" species is very abundant along the banks of Pine River and shores of the lakes of this region. It together with the skunk furnishes the fur dealer his chief supply of fur. No black muskrats have been obtained at Alma so far as known.

19. Zapus hudsonius hudsonius Zimmerman. Hudson Bay Jumping Mouse. The writer has not obtained a live specimen. One specimen in the Hood Museum is in the Stillwell collection from "Alma."

20. Erethizon dorsatum Linnaeus. Canada Porcupine. There are no recent records for the porcupine known to the writer. They are said to have been found occasionally as late as the seventies and early eighties.

21. Lepus americanus Erxleben. Varying Hare. The varying hare is occasionally taken in the more extensive swamp areas. The writer has seen them at the local markets brought in by hunters. None have been seen for two winters. It was formerly abundant but seems to have disappeared largely as the cotton tail increases.

[6]Osgood, W. H. North Ann. Fauna No. 28, p 79, 1909.

[7]Hahn, Walter Louis. The Mammals of Indiana. Ann. Rept. Dept. Geol. Nat. Resources of Indiana, 1908, p 502.

22. Sulvilagus floridanus Mearnsi Allen. The common Rabbit. Cottontail. This is abundant and does considerable damage to young orchards. It is said to have entered the region as settlement advanced.

23. Lynx canadensis Kerr. Canada Lynx. The writer has not been able to centainly confirm reported records of this species in this vicinity. There is little doubt but that it formerly occurred here. One specimen in the Museum taken near here is not clearly referable to this species.

24. Lynx ruffus Gueldenstaedt. Red Lynx. The "Wildcat" or "Bob cat," occasionally invades this area. In 1908 one was killed by Mr. Alie Douglass near Breckenridge.

25. Urocyon cinereoargentatus Schreber. Gray Fox. This fox is undoubtedly rare in the central part of the state. It is occasionally reported, and was formerly more common.

26. Vulpes fulvus Desmarest. Red fox. The red fox is still holding its own in certain sections. For the last five winters the writer has seen from one to two or three skins of the red fox brought to our local dealer Mr. Polasky by hunters. In winter of 1910-11 the skin of a "Cross Fox" was exhibited by Mr. Polasky.

27. Canis occidentalis Richardson. Gray Wolf. Timber Wolf. A Mr. Redman who lived in this vicinity at the time of its early history says that he has heard them many times. In 1872 Mr. A. R. Barbour while driving logs in Pine Pine River was overtaken by nightfall and wolves at a point between Alma and St. Louis and spent the night in a tree. If this be a correct account it is probably one of the latest records of their occurrence in this region.

28. Ursus americanus Pallas. Black Bear. Mr. W. H. Howe stated that he helped chase a bear across the county twenty years ago.

29. Procyon lotor Linnaeus. Racoon. The racoon is taken occasionally by hunters. Mr. Polasky the local dealer receives a number of raccoon skins every winter. One Albino specimen is in the Hood Musenm.

30. Taxidea tuxus Schreber. American Badger. The museum specimens are said to have been taken here. In February, 1908 a farmer living about five miles southwest of Alma took a fine specimen and brought it to the Hood Museum. It may be said to be uncommon. Thompson Seton[8] limits its range to southern Michigan and southward.

31. Mephitis putida Boitard. Eastern skunk. This species is abundant in localities. A farmer near Breckenridge secured six specimens at one time this winter under an old building. The local dealer receives large numbers every season.

32. Lutra canadensis Schreber. Canada Otter. No good record is found. It is stated that one was chased across the Northwest part of this county in 1906. An Indian trapper from Mt. Pleasant took one on Pine River a few miles above Alma in 1909.

33. Mustela americana Turton. American Marten. From what appears to be authentic accounts this species was probably found in this region as late as twenty-five years ago. There are no recent records known.

34. Mustela pennanti Erxleben. Fisher. As this is one of the

[8]The lives of northern animals. 1910 New York.

forms to disappear early it is difficult to get thoroughly reliable records. However, there is little question that it formerly was present. As it is said to feed upon hares, porcupines, birds and small mammals, it is difficult to see why it should be called Fisher. There is a skin of one in the museum but with no data.

35. Lutreola vison Schreber. Northeastern Mink. A few specimens of this species have been taken in recent years in Pine River near Alma. In 1909 some Indian trappers from Mt. Pleasant took one from a point on the river a few miles above Alma.

36. Putorius noveboracensis. Emmons. New York Weasel. This weasel is of frequent occurrence. A number of skins are received each winter by the local dealer.

37. Blarina brevicauda. Say. Short-tailed Schrew. This species has been taken in a low woods northwest of Alma, (1909) and Mr. Charles Murphy brought a specimen to the writer in 1910.

38. Condylura cristata Linnaeus. Star-nosed Mole. This species is more common than the following species. It is abundant in the low moist grounds where its presence is shown by its work.

39. Scalops. aquaticus machrinus. Rafinesque. This subspecies is reported from Indiana, Wisconsin, and Minnesota, but I believe not from this part of Michigan. Its diagnostic characters: large size, broad feet, scantily haired, relatively short tail and measurements of body and skull place the specimen in this subspecies. It occasionally injures the growth of grass in the lawns by burrowing at the roots of the plants, but it is more beneficial than injurious, because of its food habits.

40. Myotis lucifugens Le Conte. Little Brown Bat. This record is based on a single museum specimen which is not in perfect condition, but it agrees with the descriptions of lucifugens. Bats are commonly seen flying summer evenings and no doubt other species are present. M. sublatus Say, Lasionysteris noctivagans Le Conte, and Lasiurus borealis Müller, probably occur here though specimens have not yet been taken.

LIST OF AMPHIBIA.

1. Necturus maculosus Rafinesque, Mud-Puppy. The Mud-puppy is common in Pine River at Alma and is frequently taken by fishermen. The Mud-puppy breeds in the flats above Wolf's bridge. They are improperly called lizards by local fishermen.

2. Amblystoma punctatum Linneaus. Spotted Salamander. Infrequent. This species is known by the yellow spots on its sides. The eggs of this species have been taken April 6th to 15th in 1909, '10 and '11 in a small perennial pond on Windsor farm. This pond is now filled to such an extent as to become nearly dry in extremely dry weather.

3. Amblystoma Jeffersonianum. Green. Jefferson's Salamander. This species has been taken in the vicinity of the pond just mentioned where its eggs have also been taken, April 6 to 10. The eggs are usually found a few days earlier than those of A. punctatum.

3. Plethodon cinereus Green. Red-backed Salamander. This little salamander is found under the bark or in the soft wood of decaying logs. It also deposits its eggs in the damp logs. Specimens and eggs were taken July 4th, 1909 in the woods on Windsor farm.

4. Diemyctylus viridescens Rafinesque. Newt. This is found in ponds. It is apparently not very common and is found only in certain localities.

5. Bufo americanus Le Conte. American Toad. This well known toad grows to large size with underparts very dark as a rule though some are lighter beneath. It is quite common in the clay and loam habitats. Specimens have been taken in pools along the river lowlands below Alma.

6. Hyla versicolor Le Conte. Tree Toad. This little Amphibian occurs in both sand and clay habitats and its call is far more familiar than its delicate coloring. It is widely distributed.

7. Hyla pickeringii Holbrook. Spring Peeper. This is to be found on the grassy margins of ponds and bayous. This, like H. versicolor, is widely distributed.

8. Chorphilus nigritus triseriatus Wied. Swamp Tree Toad. The swamp tree toad is very shy in the field but when brought into the laboratory it is soon at ease. It is one of the earliest to sing in the spring in the pools filled by the late snow or early rains. Specimens were taken in April, 1909, in temporary ponds on Windsor farm.

9. Rana sylvatica cantabrigensis Baird. Wood Frog. The Wood Frog is very common in low wet hard-wood forests. These frogs are more numerous in woods on clay loam or sandy loam where transient pools of water are found. Windsor and Elmwood farms.

10. Rana pipiens Schreber. Leopard Frog. This is our most common Amphibian. It is found along streams, ponds and lakes and grassy meadows. This frog often wanders for from the pools. Specimens were taken in the swampy river banks below Alma.

11. Rana clamitans Latreille. Green Frog. This species is found along low banks of streams, bayous of Pine River and borders of lakes, prefering shaded and protected habitats. Specimens were taken from a lagoon in Church's park Alma.

12. Rana catesbiana Shaw. Bull Frog. The Bull Frog has been taken in Pine River and at Half Moon Lake in June, 1909.

Other species which are believed to occur here are Acris gryllus Le Conte; Rana palustris Le Conte, but specimens have not been taken.

H. MacCURDY.

Alma College, Alma Michigan, April, 1912.

CHECK-LIST MICHIGAN LEPIDOPTERA.

I. RHOPALOCERA (BUTTERFLIES).[1]

BY W. W. NEWCOMB.

One of the chief objects in presenting at this time a list of the butterflies of Michigan is the hope that it will stimulate other observers to publish their records, particularly of the occurrence of species as yet unknown in the state, and thus increase our knowledge of the subject.

In 1893, R. H. Wolcott published a list of the butterflies of Grand Rapids, Michigan,[2] in 1905, A. G. Ruthven a list from Isle Royale and the Porcupine Mountains,[3] and in 1908, C. C. Adams a list from Isle Royale.[4] These are the only lists of Michigan butterflies which have been published. Wolcott mentioned 79 species (in reality 77 species), to which the two lists just named added 6 more. The present list contains the names of 18 additional species, all but one (*Thecla cecrops*) collected or observed either in southeastern Michigan or in Dickinson County in the Upper Peninsula. The total number of butterflies now known from Michigan is 101 not including varieties and forms. I have seen Michigan specimens of all forms except the following seven species: *Apatura clyton*, *Neonympha mitchelii*, *Libythea bachmani*, *Thecla niphon*, *Catopsilia eubule*, *Thymelicus powschiek*, and *Nisoniades lucilius*.

There are a few other species which may possibly occur in the state, e. g., in the genus *Thecla*, *melinus*, *henrici* and especially *polios*, which is found in the Chicago district and in New York State, in the genus *Lycaena*, *scudderii* found in Ontario, New York State, etc., in the genus *Anthocharis*, *genutia* and *olympia*, the latter of which is known from Lake County, Indiana, not far from Michigan, and in the genus *Pamphila*, *hianna* and *uncas* and possibly *huron*, *phylacas*, *fusca* and *metea*.

Of the recorded species, more definite records of *Thecla niphon* and *Catopsilia eubule*, which were not made from captured specimens, would be highly desirable. There are a few species which are known in only one or two individuals, as *Grapta satyrus*, *Libythea bachmani*, *Thecla cecrops* and *Colias caesonia*. Further records of these and of the rarer or less known species as *Phycyodes ismeria*, *Chionnobas jutta*, *Calephelis borealis*, *Thecla strigosa* and *irus*, *Chrysophanus helloides*, *dorcas* and *epixanthe*, *Lycaena saepiolus*, etc., should be made.

All of the butterflies from Grand Rapids have been taken in southeastern Michigan except eight. These are: *Phyciodes ismeria*, *Apatura clyton*, *Neonympha mitchelii*, *Libythea bachmani*, *Thecla niphon*,

[1]Prepared for the Michigan Geological and Biological Survey and published by permission of the Chief Naturalist.

[2]Robt. H. Wolcott: Butterflies of Grand Rapids, Mich., Can. Ent., 25, 98-107.

[3]A. G. Ruthven: Spiders and Insects from the Porcupine Mountains and Isle Royale, Michigan, An Ecological Survey in Northern Michigan, 102-104.

[4]Chas. C. Adams: An Ecological Survey of Isle Royale, Lake Superior, 267-277.

Thymelicus poweschick, *Pamphila sassacus* and *Nisoniades lucilius*. The latter, however I feel certain of finding in the near future.

An interesting variety of *Limentis archippus*, namely Strecker's *pseudo-dorippus* has been recently redescribed by John H. Cook, under the name of *lanthanis*. My authority for this statement is W. J. Holland. I mention this, as a good example of this variety has been taken in Dickinson County.

It would indeed be fortunate if the students of the Lepidoptera were agreed as to the nomenclature to be used. There have been two great students of American butterflies, W. H. Edwards and S. H. Scudder, each of whom has held different ideas as to classification, especially in relation to genera. The result has been two groups of followers and two classifications of North American butterflies. I express no preference for either, hoping that some day not far off, the Lepidopterists of the country can agree upon one set of names. In the present list I have followed Skinner, (who represents the Edward's group of students) in Smith's Check-List of the Lepidoptera of Boreal America.

LIST OF SPECIES.[1]

NYMPHALIDAE.

Danainae.

1. **Danais plexippus** Linn.

Nymphalinae.

2. **Euptoieta claudia** Cram.
3. **Argynnis idalia** Dru.
4. **cybele** Fabr.
5. **aphrodite** Fabr.
   cypris Edw.*
   alcestis Edw.
6. **atlantis** Edw.*
7. **myrina** Cram.
8. **bellona** Fabr.
9. Melitaea **phaeton** Dru.
10. **harrisii** Scudd.
11. **Phyciodes nycteis** Db. & Hew.
12. **ismeria** Bd. & Lec.
13. **tharos** Dru. **marcia** Edw.
    morpheus Edw.
14. **Grapta interrogationis** Fabr. **fabricii** Fabr.
    umbrosa Lint.
15. **comma** Harr. **harrisii** Edw.
    dryas Edw.
16. **Satyrus** Edw.*
17. **faunus** Edw.*[2]
18. **progne** Cram.

[1]Species and forms which are known only from the Upper Peninsula are marked with an asterisk.

[2]*Faunus* has been recorded from the Porcupine Mountains as *gracilis*, a misidentification. See "An Ecological Survey in Northern Michigan," 102. While *Grapta gracilis* will probably be found in the Upper Peninsula, no actual record has yet been made.

19. j-album Bd. & Lec.
20. Vanessa antiopa Linn.
21. milberti Godt.
22. Pyrameis atalanta Linn.
23. huntera Fabr.
24. cardui Linn.
25. Junonia coenia Hbn.
26. Limenitis ursula Fabr.
27. arthemis Dru.
28. archippus Cram.
pseudo-dorippus Strck.*
29. Apatura clyton Bd. & Lec.

Satyrinae.

30. Debis portlandia Fabr.
31. Neonympha canthus Bd. & Lec.
32. eurytus Fabr.
33. mitchelii French.
34. Satyrus alope Fabr. nephele Kirby.
35. Chionobas jutta Hbn.*

LIBYTHEIDAE.

36. Libythea bachmani Kirtl.

ERYCINIDAE.

Erycininae.

37. Calephelis borealis G. & R.

LYCAENIDAE.

Lycaeninae.

38. Thecla acadica Edw.
39. edwardsii Saund.
40. calanus Hbn.
41. strigosa Harr.
42. cecrops Fabr.
43. augustus Kirby.
44. irus Godt.
45. niphon Hbn.
46. titus Fabr.
47. Feniseca tarquinius Fabr.*
48. Chrysophanus thoe Bdv.
49. helloides Bdv.
50. dorcas Kirby.
florus Edw.
51. epixanthe Bd. & Lec.
52. hypophlaeas Bdv.
53. Lycaena saepiolus Bdv.*
54. lygdamas Doub.
55. pseudargiolus Bd. & Lec. marginata Edw.
violacea Edw.
neglecta Edw.
56. comyntas Godt.

PAPILIONIDAE.

Pierinae.

57. **Pieris protodice** Bd. & Lec.
vernalis Edw.
58. **napi** Linn. **oleracea-aestiva** Harr.
59. **rapae** Linn.
immaculata Sk. & Aar.
60. **Catopsilia eubule** Linn.
61. **Colias caesonia** Stoll.
62. **eurytheme** Bdv.
63. **philodice** Godt.
luteitincta Wolcott.
64. **interior** Scudd.*
65. **Terias lisa** Bdv.

Papilioninae.

66. **Papilio ajax** Linn. **walshii** Edw.
abbottii Edw.
telamonides Feld.
marcellus Edw.
67. **philenor** Linn.
68. **polyxenes** Fabr.
69. **troilus** Linn.
70. **glaucus** Linn. **turnus** Linn.
71. **thoas** Linn. **cresphontes** Cram.

HESPERIDAE.

72. **Ancyloxypha numitor** Fabr.
73. **Thymelicus poweschiek** Park.
74. **Pamphila massasoit** Scudd.
75. **hobomok** Harr.
pocohontas Scudd.
76. **sassacus** Harr.
77. **leonardus** Harr.
78. **otho** S. & A. **egeremet** Scudd.
79. **peckius** Kirby.
80. **mystic** Scudd.
81. **manataaqua** Scudd.
82. **cernes** Bd. & Lec.
83. **verna** Edw.
84. **metacomet** Harr.
85. **bimacula** Edw.
86. **pontiac** Edw.
87. **dion** Edw.
88. **vitellius** Fabr. **delaware** Edw.
89. **viator** Edw.
90. **Amblyscirtes vialis** Edw.
91. **Pyrgus tessellata** Scudd.
92. **Nisoniades brizo** Bd. & Lec.
93. **icelus** Lint.
94. **lucilius** Lint.
95. **persius** Scudd.
96. **juvenalis** Fabr.

97. Pholisora catullus Fabr.
98. Eudamus pylades Scudd.
99. bathyllus S. & A.
100. tityrus Fabr.
101. proteus Linn.

ON SOME AMPHIBIANS AND REPTILES FROM THE STATE OF VERA CRUZ, MEXICO.[1]

ALEXANDER G. RUTHVEN.

Through the kindness of the Director, Mr. Frederick J. V. Skiff, and the Assistant Curator, Dr. S. E. Meek, of the Field Museum of Natural History, I have recently been able to examine the amphibian and reptile material in that institution that has been received from the southern part of the State of Vera Cruz, Mexico. The principal value of this collection is in the additional locality records that it gives, and the following list has been prepared for the purpose of making this data available to students of distribution.

As the localities represented by the collection are mostly unrecorded on the maps it is necessary to give their situations. With three exceptions they are small villages along the Vera Cruz al Istmo Railroad, the northern terminals of which are Cordoba and Vera Cruz, the southern Santa Lucrecia on the Isthmus of Tehauntepec. This railroad runs rather directly southeast from Cordoba to Santa Lucrecia, and the Vera Cruz branch from Vera Cruz to Tierra Blanco, so that the location of the stations can be given conveniently in kilometers from the terminals.

Achotal, on the Vera Cruz al Istmo R. R., 40 Kilometers from Santa Lucrecia.

Boca del Rio, at the mouth of the Jamapo River and on the Vera Cruz al Istmo R. R., 12.8 Kilometers southeast of Vera Cruz.

La Antigua, on the Interoceanic R. R., 35 Kilometers northwest of Vera Cruz.

Motzorongo, on the Vera Cruz al Istmo R. R., 41.5 Kilometers from Cordoba.

Obispo, on the Vera Cruz al Istmo R. R., 160.5 Kilometers from Santa Lucrecia.

Orizaba, Vera Cruz.

Otopa (probably a village at Rio Otopa) on the Vera Cruz al Istmo R. R., 67.9 Kilometers from Vera Cruz.

Perez, on the Vera Cruz al Istmo R. R., 125.3 Kilometers from Santa Lucrecia.

San Francisco, on the Interoceanic R. R., 43 Kilometers northwest of Vera Cruz.

Vera Cruz, Vera Cruz.

Xuchiles, on the Vera Cruz al Istmo R. R., 23.6 Kilometers from Cordoba.

[1]From the University of Michigan Museum of Natural History.

LIST OF SPECIES.

Spelerpes variegatus (Gray.) One specimen (1485) from Achotal.

Rana palmipes Spix. Ten specimens (1368) from Perez.

Leptodactylus caliginosus Girard. Single specimens from Achotal (1483) and Obispo (1366).

Bufo valliceps Wiegmann. One specimen (1687) from Perez.

Hyla baudini Dumeril and Bibron. Five specimens (1686) from Perez.

Anolis biporcatus (Wiegmann). Three specimens (1477) from Achotal establish another definite Mexican locality for this species.*

Anolis sallaei Gunther. Three specimens (1477, 1478) from Achotal.

Basiliscus vittatus Wiegmann. One specimen (1329) from Rio Blanco and one (1685) from Perez.

Ctenosaura acanthura completa (Bocourt). One young specimen (1921) from La Antigua and five from San Francisco.

Sceloperus variabilis Wiegmann. Ten specimens (1331) from San Francisco, two (1258) from Motzorongo, ten (1684) from Perez, ten (1327) from Rio Blanco, twelve (1342) from Vera Cruz, ten (1491) from La Antigua, and eleven (1476) from Achotal.

Sceloperus formosus Wiegmann. Three specimens (1521) from Xuchiles.

Ameiva undulata (Wiegmann). One specimen (1314) from Otopa, four (1318) from Perez, one (1303) from Boca del Rio, one (1308) from Obispo, and three (1479) from Achotal.

Cnemidophorus guttatus Wiegmann. One specimen (1328) from Rio Blanco, eight (1492) from La Antigua, six (1683) from Perez, two (1314) from Otopa, and four (1330) from San Francisco.

Cnemidophorus deppei Wiegmann. Three (1313) from Otopa, four (1343) from Vera Cruz, and four (1683) from Perez.

Ficimia olivacea Gray. One specimen (1315) from Otopa.

Contia nasus (Gunther). A single specimen (1462) from Orizaba.

*See Ruthven, Alexander G. Zool. Jahr., Bd. 31, Abt. f. Syst., p. 311.

A PRELIMINARY HOST INDEX OF THE FUNGI OF MICHIGAN, EXCLUSIVE OF THE BASIDIOMYCETES, AND OF THE PLANT DISEASES OF BACTERIAL AND PHYSIOLOGICAL ORIGIN.

G. H. COONS, RESEARCH ASSISTANT IN PLANT PATHOLOGY MICHIGAN AGRICULTURAL COLLEGE.

For some time the need for a rearrangement of the lists of the fungi known to occur in Michigan has been felt. Moreover while the large collection of fungi at Ann Arbor had been listed and the records made available, the collection at the Michigan Agricultural College has never been listed and for the most part the records were unavailable for use in determining species and reporting range.

In the winter of 1912 I set about examining the herbarium of the College, and decided instead of publishing a mere supplementary list of unreported species, to incorporate the lists already published by Pollock and Kauffman, '05, into the records of the College and get out a provisional Host Index. Lack of time required that the Smuts, Rusts and the higher Basidiomycetes be excluded but it is hoped that this additional work can soon be done. With this list of the fungi, there has also been incorporated a list of the bacterial diseases of plants and a list of the physiological and obscure diseases, so far as they are represented by specimens or reported in an authentic way. This last addition is thought to be a matter of convenience, since many of these obscure diseases present puzzling symptoms, or are apt to be confused with the first stages of diseases of fungous origin.

The collection of fungi in this state began about 1885, with the work of Spalding at Ann Arbor and of Beal at M. A. C. The greater part of the collections at M. A. C., were made by Gilbert H. Hicks, instructor in Botany from 1890 to 1895, and his accurate determinations give authority to the lists now published. Working about the same time with Hicks, but at Ann Arbor, L. N. Johnson amassed and named the greater part of the fungi reported by Pollock and Kauffman in 1905. These men, Hicks and Johnson, were in close touch with each other, exchanging specimens, and they also were esteemed correspondents of the eminent mycologists of America, Ellis, Peck and Farlow. C. F. Wheeler well known for his extensive work on the higher plants of the state contributed many specimens and records, and B. O. Longyear, '02, gave impetus to the listing of the fungi of the state by publishing his Preliminary List of the Saprophytic Fungi of Michigan, a work which has been carried out to great completeness for the Hymenomycetes by Dr. C. H. Kauffman, of the University of Michigan. These lists published annually in the Reports of the Michigan Academy of Science have added immensely to the knowledge of the flora of the state as well as aroused great interest in the lower forms. Along with these lists the last three reports by Kauffman have contained helpful, work-

able keys to such difficult groups as the Gasteromycetes, 1908, the Russulas, 1909, the genera of Asycomycetes and Basidiomycetes, with a field key to the species of the Polyporaceae, in 1911. At present Dr. Kauffman is completing a monograph of the Hymenomycetes of Michigan to be published by the Michigan Geological and Biological Survey. Following the lead of Longyear, Pollock and Kauffman, '05, listed the specimens found in the University of Michigan Herbarium adding whatever of records they themselves could. This list included the Fungi Imperfecti (Pollock), the Ascomycetes and Basidiomycetes (Kauffman). The Phycomycetes were not included, nor were the Rusts and Smuts. A partial list of the Phycomycetes was added by Kauffman in a latter list, 1906. The only article on the Uredineae of the state was written by Miss Harriet L. Merrow an instructor in Botany at the University, but this was published only in abstract in the First Report of the Michigan Academy of Science. Miss Merrow besides this list of the Uredimeae supplied many speciments to various exsiccati. Various students of Dr. Beal added specimens to the M. A. C. Herbarium and in 1900 Bronson Barlow was employed to collect plants in the Upper Peninsula.

Michigan is but seldom mentioned in the general literature of Mycology and Plant Diseases. This is due entirely to the fact that reports for the state before the publications mentioned above, were very meager and scattered. Underwood, '99, states: "In this state no local publications aside from some notices of a few economic species have been issued although collections have been made by Professors Wheeler and Spalding, Mr. G. H. Hicks and others. It is doubtful if there are one hundred species all told recorded in any publication as found in the state," a very decided contrast to the condition of mycology in Wisconsin whose fungous flora has become well known and quickly available through the pioneer work of Dr. William Trelease and the continued efforts of J. J. Davis.

Dr. Erwin F. Smith traveled extensively in Michigan while studying the diseases of peach, (chiefly yellows) from 1887 till about 1893. The reports of his work on peach yellows are well known and are the classic on the subject. He reported other observations on various diseases in a series of Field Notes, '90, '91, '92. These have been extensively quoted and are in many cases the first observations on the parasitism of a given organism. Further notes on the occurrence of plant diseases, especially bacterial diseases are found in later articles by Smith, '05, '11.

Of course during the long period of agricultural and horticultural work by the College, many articles have appeared on plant diseases, but these records along with those from Horticultural Societies, articles in the farm press, etc., are difficult to find, to identify positively and to locate as to occurrence. For many years the Horticultural Department has issued spraying calendars, but these from their very nature are popular and not intended for an exact report of species and localities.

Two publications directly applied to Michigan conditions and founded for the most part upon observations of the authors upon Michigan diseases appeared in 1905. These were Longyear, Fungous Diseases of Fruits in Michigan, and Sackett, Some Bacterial Diseases of Plants

Prevalent in Michigan. Both were, from their nature, compilations but they embody many original observations of the authors and are illustrated, for a large part at least, with original plates and figures. However the lack of extensive collections and the absence of an extensive literature made many of the statements vague and some fungi and some diseases are reported for which there is no herbarium material, nor any definite statement of locality or collector.

In the list following a very full citation of the localities and the dates of collection is given. This is largely to serve to identify a given collection, to hint the prevalence and the time of year the fungus is found. Of course the information is entirely too meager to permit any conclusions, or to give any idea of the range. This Host Index may however stimulate collections and it is hoped that this method of listing the species may help to make identifications more easy. The arrangement of hosts has followed the Michigan Flora (Beal, '05) with the cultivated plants interpolated in the proper families. This arrangement keeps closely related groups together and frequently a fungus which has not been listed upon one species will be given for a closely related plant.

In nomenclature for M. A. C. collections the names given in the North American Flora, insofar as that work has progressed, has been employed. For the Erysiphaceae, Salmon, '00, has been adopted, while for the Exoascaceae, the work of Atkinson '95, and Patterson '95, has been followed. The monograph of Wilson, '07, has been followed for the Phycomycetes. For the remaining groups for which no recent comprehensive treatment including American forms has appeared, the determination unless otherwise stated is on the authority of the collector. All M. A. C. specimens have been inspected and it is hoped that the determination at least to genus is accurate. The men who have collected the material for the M. A. C. Herbarium (and for the University also) were close students of the Ellis and Everhart publications and exsiccati, and such deviation from the names employed today may be expected in the list here given as is found in the names employed in the North American Fungi. For the University of Michigan collections the names and authorities given by Pollock and Kauffman (in the main the names given by Johnson) have been copied without attempt at transposition, except in the case of the groups covered by the North American Flora, or in cases where the name given is the one associated with a conidial form for which the perfect form is now definitely known.

It is hoped that this catalogue will make the collections of the Michigan Agricultural College available for those engaged in monographic work. Duplicates where possible, will be furnished, or at least the loan of collections will be gladly made.

OSMUNDACEÆ.

Osmunda cinnamonea L.

Gloeosporium osmundae E. & E. Munith, August, 1893, Hicks, N. A. F.,** 3073.

POLYPODIACEÆ.

Onoclea sensibilis L.

Phyllactinia corylea (Pers.) Karst. M. A. C., 10-9-92, Hicks.

Septoria mirabilis Pk. Battle Creek, 8-19-1885, Spalding, M.*

Asplenium angustifolium Michx.

Septoria asplenii E. & E. M. A. C., 10-2-1891, Hicks, M. (*cotype.*)

Pteridium aquilinum (L.) Kuhn.

Leptostromella filicina (B. & C.) Sacc. M. A. C., 5-19-1892, Hicks.

EQUISETACEÆ.

Equisetum hyemale L.

Stamnaria equiseti (Hoffm.) Sacc. M. A. C., Oct. 3, Wheeler and Hicks.

ARAUCARIACEÆ.

Araucaria.

Hormodendrum cladosporioides Sacc. A. A., *fide* Pollock '05, p. 56, 57.

PINACEÆ.

Pinus sp.

Helicoon ellipticum (Pk.) Mag. A. A., Sept., 1894, Johnson, M.

Fusarium sp. "Damping of" For Mich. *fide* J. B. Pollock.

Phoma strobiligena Desm. (on cone). A. A., 4-5-93, Johnson, M.

Larix laricina (Du Roi) Koch.

Dasyscypha willkommii Hartig. Washtenaw Co., June 3, *fide* Kauffman, M.

Valsa ambiens (Pers.) Fr. A. A., March and April, *fide* Johnson, M.

Picea mariana (Mill.) B. S. P.

Dasyscypha calycina (Schum.) Fckl. (*Willkommi*). N. Mich. *fide* Durand.

Juniperus.

Valsa cenisia DeNot. A. A., April, *fide* Ellis, M.

ALLSMACEÆ.

Sagittaria latifolia Willd.

Cercospora sagittariae E. & K. A. A., July and Sept., Johnson and Spalding, M; Saginaw, Waite, 9-4-1889, U. S. D. A. Herb. 10.

GRAMINEÆ.

In general are affected with *Erysiphe graminis* DC.

Andropogon furcatus Muhl.

Phyllachora graminis (Pers.) Fckl. Park Lake, 9-2-90, Beal and Wheeler.

Panicum dichotomum L.

Phyllachora Panici Schw. Munith, Aug., 1893, Hicks.

**North American Fungi, Ellis and others.

* "M" after a collection indicates that the material is at University of Michigan, otherwise the collection is at M. A. C.

Panicum porterianum Nash.
Septoria graminum Desm. M. A. C., 1896, Wheeler.
Phyllachora graminis (Pers.) Fckl. M. A. C., Clark, Hicks.
Chaetochloa italica (L.) Scribn.
Sclerospora graminicola (Sacc.) Schroet. M. A. C., '97, Beal.
Reported for Mich. by Wilson, '07, p. 396 (Collection by Wheeler). M. A. C., Crozier, Aug., 1896; M. A. C., Wheeler, 9-9-96.
Chaetochloa viridis (L.) Scribn.
Sclerospora graminicola (Sacc.) Schroet. M. A. C., Longyear.
Zizania aquatica L.
Mycosphaerella zizaniae Schw. M. A. C., 1890, (?) Beal.
Phalaris arundinacea L.
**Spermoedia clavus* (D. C.) Fr. (Ergot). M. A. C.
Oryzopsis asperifolia Michx.
Asterina graminicola E. & E. M. A. C., May, 1892, Hicks, *fide* Ellis. (cotype)
Mycosphaerella orysopsidis E. & E. M. A. C., May, '93, *fide* Hicks. (cotype.)
Muhlenbergia.
Phyllachora muhlenbergiæ (E.) Sacc. Sept., '86.
Muhlenbergia diffusa Willd.
Fusarium graminum Corda. M. A. C., 9-29-96, Wheeler.
Muhlenbergia mexicana (L.) Trin.
Phyllachora. M. A. C., 9-8-89.
Phyllachora graminis (Pers.) Fckl. Lansing, Waite, 9-5-89, U. S. D. A., Herb., 30.
Brachyelytrum erectum (Schreb.) Beauv.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-17-91, Hicks.
Phleum pratense L.
**Spermoedia clavus* (D. C.) Fr. Grayling, Walton, M. A. C., Aug. to Oct., Beal.
Scolecotrichum stictieum (B. & Br.) Sacc. M. A. C., 9-20-01, Beal.
Alopecurus pratensis L.
**Spermoedia clavus* (D. C.) Fr. Walton, 10-11-89, Beal.
Agrostis alba L.
**Spermoedia clavus* (D. C.) Fr. M. A. C., Aug., '90, Beal.
Calamagrostis canadensis (Michx.) Beaur.
Phyllachora graminis (Pers.) Fr. M. A. C., 8-24-89.
Avena sativa L.
Macrosporium sp. M. A. C., 7-15-94, Stevens.
Arrhenatherum elatius (L.) Beauv.
**Spermoedia clavus* (D. C.) Fr. Walton, 11-11-89, Beal.
Dactylis glomerata L.
Scolecotrichum graminis Fckl. M. A. C., 9-24-89, Beal.
**Spermoedia clavus* (D. C.) Fr. Au Sable, 10-5-89; M. A. C., 8-28-90, Beal.
Poa pratensis L.
Erysiphe graminis D. C. M. A. C., 9-30-89, Dewey.
Septoria graminum Desm. M. A. C., 5-24-98, Wheeler.
Panicularia canadensis (Michx.) Kunze.
Typhodium typhina (Pers.) Seaver. M. A. C., Aug., 88; M. A. C., 5-24-86, *fide* Farlow.

*Claviceps purpurea Tul. Ergot.

Panicularia fluitans (L.) Kuntze.
Typhodium typhina (Pers.) Seaver (*Epichloe*). Port Huron, 6-16-93, C. K. Dodge; Klinger Lake, 6-6-90, Wheeler.
Scolecotrichum graminis Fckl. Battle Creek, A. A., July, Spalding, Pieters, M.
Festuca octoflora Walt.
**Spermoedia clavus* (D. C.) Fr. 1884, data lost, prob. M. A. C.
Bromus secalinus L.
Fusarium. M. A. C., 9-12-96, Wheeler, *fide* Beal.
Bromus inermis Leyss.
**Spermoedia clavus* (D. C.) Fr. M. A. C., Sept., '89 (Seed from Russia).
Agropyron caninum (L.) R. & S.
**Spermoedia clavus* (D. C.) Fr. M. A. C., 7-10-90.
Agropyron smithii Rydb.
**Spermoedia clavus* (D. C.) Fr. M. A. C. 8-7-90, Beal; M. A. C., Sept., 91.
Agropyron repens (L.) Beauv.
Erysiphe graminis (D. C). M. A. C., 6-27-93, Beal.
**Spermoedia clavus* (D. C.) Fr. M. A. C., 8-31-92, Beal.
Secale cereale L.
**Spermoedia clavus* (D. C.) Fr. M. A. C., 1900, Beal; Au Sable, 10-5-89; A. A. Aug. *fide* Johnson; Smith, '89, reports for east shore of Lake Mich., South Haven and St. Joseph, but not found in central part of state.
Elymus canadensis L.
Phyllachora graminis (Pers.) Fckl. M. A. C., 10-27-85, Sept., '85.
**Spermoedia clavus* (D. C.) Fr. M. A. C., 9-6-90, Beal.
Elymus striatus Willd.
Phyllachora graminis (Pers.) Fckl. Dimondale, Oct., '90, Beal.
Elymus virginicus L.
Phyllachora graminis (Pers.) Fckl. M. A. C., (?) 10-27-85; Lansing, Waite, 9-5-89, U. S. D. A., Herb., 29.
Hystrix hystrix (L.) Millsp.
Phyllachora graminis (Pers.) Fckl. Dimondale, 10-10-90, Beal. M. A. C., 9-24-89, Beal; Sept., 1911, Bessey.
Zea mays L.
Bacillus sorghio Burr. Reported for Mich. by Stevens and Hall., '10, p. 362.
Bacterium stewarti Smith. Reported for Mich. by Smith, '11, p. 60.
Diplodia maydis (Berk.) Sacc. M. A. C., 5-7-93, Johnson, M.
Epicoccum neglectum Desm. M. A. C., Nov. and Dec., '91, Hicks.
Fusarium spp. (Ear Rots). M. A. C., Apr., 1912, Coons.
Leptosphaeria eustoma (Fr.) Sacc. A. A., Nov. 25 *fide* Ellis, M.
Trichosporium sphaericum Sacc. A. A., 11-25-94, Johnson, M.
Triticum vulgare L.
Alternaria. Holland, *fide* Barlow.
Erysiphe graminis D. C. M. A. C., July, '92, Beal and Hicks.
Fusarium graminum Corda var. *tritici* Kühn. M. A. C., July 14, *fide* Farlow; Hillsdale, '98; Marshall, 7-3-05, Beal; Manchester, 6-30-05; M. A. C., July, '92, Hicks; Chatham, 6-18-02, Geismar *fide* Beal.
Phyllachora graminis (Pers.) Fckl. M. A. C., April, 1911, Coons.
**Spermoedia clavus* (D. C.) Fr. M. A. C., (?) '96, Crozier; M. A. C., 7-11-93, F. S. Scott; Harrisville, Sept., '09; Benzonia, 83.

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*Claviceps purpurea Tul. Ergot.

CYPERACEÆ.

Eleocharis.
Cladosporium herbarum (Pers.) Lk. A. A., Sept. and Dec., '93, Pieters *fide* Ellis, M.

Carex.
Cladosporium herbarum (Pers.) Lk. M. A. C., 5-19-92, Hicks.

ARACEÆ.

Peltandra virginica (L.) Knuth.
Ramularia. M. A. C., 8-27-90.

Symplocarpus foetidus (L.) Nutt.
Cercospora symplocarpi Pk. M. A. C., 7-25-86, Beal; A. A., 8-25-94, Pieters, M.

Monstera deliciosa Liebm. (*Philodendron pertusum.*)
Macrophoma philodendri Pk. M. A. C. (greenhouse), May, '92, Hicks.

LILIACEÆ.

Yucca.
Coniothyrium concentricum Desm. M. A. C., April, '92, Hicks.

Hyacinthus.
Bacillus hyacinthi-septicus Heinz. (?) M. A. C., April, 1912, Coons. (Soft Rot)

Allium canadense Kalm.
Vermicularia liliacearum West. A. A., May and July, Merrow, Johnson, M.

Lilium.
Botrytis sp. ("Ward's Lily Disease"). M. A. C., 7-3-01, Wheeler; Benton Harbor, June, '04, *fide* Longyear.

Lilium superbum L.
Macrosporium. M. A. C., 8-22-97, Wheeler.

CONVALLARIACEÆ.

Vagnera racemosa (L.) Morong.
Septoria smilacinae E. & M. M. A. C., 9-24-87, *fide* Beal; M. A. C., 9-9-91, Hicks; M. A. C., 7-4-92, Hicks.

Vagnera stellata (L.) Morong and **racemosa** (L.) Morong.
Phyllosticta cruenta Kickx. A. A., July, '92, Merrow, Spalding, M.

Vagnera stellata (L.) Morong.
Septoria smilicinae E. & M. Munith, 8-14-93, Hicks.

Unifolium canadense (Desf.) Greene.
Phyllactinia corylea (Pers.) Karst. M. A. C., 17-17-91, Hicks.

Trillium grandiflorum (Michx.) Salisb.
Septoria trillii Pk. M. A. C., Aug., 1911, Coons.

Trillium erectum L.
Septoria trillii Pk. A. A., 5-26-94, Johnson, M.

SMILACEÆ.

Smilax.
Phyllosticta smilacis E. & M. A. A., 8-8-94, Merrow *fide* Ellis, M.

Smilax herbacea L.
Cercospora smilacis Thüm. M. A. C., 9-24-89, Beal.

Smilax hispida Muhl.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-21-92, Hicks.

Helminthosporium petersii B. & C. M. A. C., 10-27-85, Beal.
Sphaeropsis smilacis E. & E. A. A., 4-8-93, Johnson, M.

DIOSCOREACEÆ.

Dioscorea villosa L. (Torr).
Cercospora dioscoreae E. & M. M. A. C., '96, Wheeler.

IRIDACEÆ.

Iris.
Macrosporium iridis C. & E. A. A., 8-2-94, Merrow, M.
Iris versicolor L.
Phyllosticta iridis E. & E. A. A., 7-12-92, Merrow, M. (cotype)
Gladiolus.
Scab, cause unknown. (Mites?)
Soft rot (*Penicillium* associated); Hard rot (Worst disease). South Haven, 2-14-11, Coons.

CANNACEÆ.

Canna indica L.
Macrosporium bulbotrichum Cke. M. A. C., 6-14-01, Wheeler *fide* Longyear.

ORCHIDACEÆ.

Cypripedium reginæ Walt.
Macrosporium. Chatham, 8-4-00, Wheeler.
Corallorhiza multiflora Nutt.
Phoma corallorhiza E. & E. M. A. C., June, '92, Hicks. (cotype)

JUGLANDACEÆ.

Juglans.
Diaporthe bicincta (C. & Pk.) Sacc. A. A., May 28, Johnson, M.
Juglans cinerea L.
Marsonia juglandis (Lib.) Sacc. Battle Creek, 8-22-85, Spalding, M.; North Lansing, 10-4-90, Beal, M.
Streptothrix atra B. & C. A. A., *fide* Ellis, M.
Juglans nigra L.
Cytospora albiceps E. & K. A. A., 3-31-93, Johnson *fide* Ellis, M.
Diplodia juglandis Fr. A. A., 3-31-93, Johnson, M.
Marsonia (Gloeosporium) juglandis (Lib.) Sacc. M. A. C., 9-22-89; North Lansing, 10-4-90, Beal *fide* Hicks; Lansing, 9-5-89, Waite.
Hicoria.
Discosia artocreas (Tode) Fr. A. A., April, May and August, Pieters, Johnson, M.
Haplographium chlorocephalum Fres. A. A., 3-23-91, Johnson *fide* Ellis, M.
Phoma exocarpi Pk. M. A. C., April, '92, Hicks. (cotype).
Ramularia albomaculata Pk. Park Lake, Sept., '99, Beal, Wheeler.
Sphaeropsis pericarpi Pk. A. A., 4-3-93, Johnson, M.
Tubercularia vulgaris Tode (*Nectria cinnabarina*). A. A., Nov., '04, Davis *fide* Pollock, M.
Valsaria isitiva Ces. & DeNot. A. A., March and April, Johnson, M.
Hicoria alba (L.) Britton.
Gloeosporium caryae E. & Dearn. M. A. C., 9-2-90, Beal, Wheeler, (also at M.)
Cytospora albiceps E. & K. A. A., 3-31-93, Johnson *fide* Ellis M.

Hicoria minima (Marsh) Britton.
Phyllactinia corylea (Pers.) Karst. M. A. C., Oct., '92, Hicks.
Hicoria ovata (Mill.) Britton.
Septoria caryae E. & E. Belle Isle, '02, Wheeler.

SALICACEÆ.

Populus.
Cenangium populneum (Pers.) Rehm. A. A., March 25, *fide* Kauffman, M.
Helicomyces elegans Morg. A. A., 4-5-95, Johnson ("Spores not so long as description") M.
Lasiosphaeria ovina (Pers.) Ces. & DeNot. A. A., Oct. 30, *fide* Ellis, M.
Nectria coccinea (Pers.) Fr. A. A., Sept., Oct., Johnson, M.
Taphrina aurea (Pers.) Fr. Washtenaw Co., May 3, *fide* Pennington, M.
Uncinula salicis (DC.) Wint. M. A. C., 9-12-11, Coons.
Valsa nivea (Hoff) Fr. A. A., April 18, Johnson, M.
Populus balsamifera L.
Septoria populicola Pk. Battle Creek, N. Mich., Sept., Spalding, Beal, M.; Thunder Bay, 8-3-95, Wheeler, *fide* Beal.
Populus grandidentata Michx.
Uncinula salicis (DC.) Wint. M. A. C., 10-13-91, Hicks.
Populus deltoides Marsh.
Cytospora chrysosperma (Pers.) Fr. Monroe, May 11, Coons, *fide* Mrs. Patterson.
Uncinula salicis (DC.) Wint. M. A. C., 10-11-91, Hicks.
Populus tremuloides Michx.
Uncinula salicis (DC.) Wint. M. A. C., 10-12-91, Hicks.
Taphrina johansonii Sadeb. M. A. C., 5-11-98, Wheeler; M. A. C., May, '92, Hicks, Fungi Columb. 1312 (under name *T. rhizophora* Johans.)
Salix.
Bacterium tumefaciens Smith and Townsend. M. A. C., Oct., 1911, Coons.
Cytospora salicis (Corda) Rab. A. A., 2-25-94, Merrow, M; Fennville, Aug. 11, Coons.
Eutypa leioplaca (Fr.) Cke. A. A., April 1, Johnson, M.
Exosporium tiliae Lk. M. A. C., Jan., '92, Hicks.
Nectria peziza Fr. A. A., Sept., Oct., Johnson, M.
Rosellinia aquila (Fr.), De Not. A. A., April 4, Johnson, M.
Trimmatostroma americana Thüm. A. A., 3-11-93, Johnson, M.
Uncinula salicis (DC.) Wint. Saginaw, Lansing, Sept., '89, Waite, U. S. D. A., Herb. 32; M. A. C., Oct., Beal; Salmon, '00, p. 83 lists for Mich.
Valsa borella Karst. A. A., April 17, *fide* Ellis, M.
Salix amygdaloides Anders.
Phialea vulgaris (Pers.) Rehm. Washtenaw Co., Nov. 12, Kauffman, M.
Salix bebbiana Sarg.
Uncinula salicis (DC.) Wint. M. A. C., 10-12-91, Hicks.
Salix cordata Muhl.
Rhytisma salicinum (Pers.) Fr. M. A. C., 9-22-89.
Salix discolor Muhl.
Rhytisma salicinum (Pers.) Fr. M. A. C., 10-2-89.
Uncinula salicis (DC.) Wint. M. A. C., 9-15-89; Dimondale, 10-10-90, Beal; M. A. C., five collections.

Salix glaucophylla Bebb.
Fumago vagans Pers. M. A. C., July and Sept., Beal and Wheeler, (also at M.).
Salix humilis Marshall.
Uncinula salicis (DC.) Wint. Isle Royale, 8-3-01, Shantz and Allen, Fung. Columb., 1688; M. A. C., 10-12-91, Hicks.
Salix interior Rowlee.
Uncinula salicis (DC.) Wint. M. A. C., 10-3-91, Hicks.
Salix lucida Muhl.
Septoria albaniensis Thüm. Battle Creek, 8-29-85; A. A., 9-8-88, Spalding, M.
Salix petiolaris J. L. Smith.
Trimmatostroma americana Thüm. M. A. C., 10-17-91, Hicks.
Uncinula salicis (DC.) Wint. M. A. C., 10-11-91, Hicks. (three collections)

BETULACEÆ.

Carpinus.
Eutypella cerviculata (Fr.) Sacc. A. A., March 11, Johnson, M.
Gnomoniella fimbriata (Pers.) Sacc. M. A. C., Sept. 10., M.
Hypoxylon howeianum Pk. A. A., May 13, Johnson, M.
Lasiosphaeria canescens (Pers.) Karst. A. A., Sept. 20, Johnson, M.
Carpinus caroliniana Walt.
Cylindrosporium dearnessii E. & E. A. A., 5-9-94, Johnson, M.
Gnomoniella fimbriata Pers., *Mamiania fimbriata* Sacc. M. A. C., 10-9-90, Yoshida.
Microsphaera alni (DC.) Wint. M. A. C., 10-10-91, Hicks.
Corylus.
Diatrype albopruinosa (Schw.) Cke. A. A., March, April, *fide* Ellis, M.
Diatrypella verruciformis (Ehr.) Nits. A. A., April 31, Johnson, M.
Gnomoniella coryli (Batsch) Sacc. Battle Creek, Aug., Sept., Spaulding, M.
Hypoxylon fuscum (Pers.) Fr. A. A., March 31, Johnson, M.
Hypoxylon perforatum (Schw.) Sacc. A. A., March, April, Johnson, M.
Corylus americana Walt.
Diatrype anomala Pk. M. A. C., Sept. '91, Hicks; A. A., 11-27-92, Hicks; Dorrisberg, Pettit.
Diplodia coryli Fckl. ("probably"). A. A., 3-24-93 and 5-17-93, Johnson, *fide* Ellis, M.
Gloeosporium coryli (Desm.) Sacc. A. A., 9-27-90, Johnson, M.
Gnomonia coryli Sacc. M. A. C., Aug. '90, Yoshido; Mackinac, July '82, Trelease; M. A. C., 9-24-92, Hicks; Saginaw, 9-4-89, Waite, U. S. D. A., Herb. 21 (*Sphaeria coryli*).
Helicomyces olivaceus Pk. A. A., April, May, '93, Johnson, M.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-1-92, Hicks; M. A. C., Sept. '93, C. F. Baker.
Microsphaera alni (DC.) Wint. M. A. C., 10-3-91, Hicks.
Septoria corylina Pk. A. A., Johnson, 9-22-94, M.
Corylus rostrata Ait.
Phyllosticta coryli West. M. A. C., 8-27-93, Hicks. (*P. corylina* Ellis?)
Ostrya virginica (Mill.) Willd.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-21-92, *fide* Coons.
Uncinula macrospora Pk. M. A. C., Oct. '92, Hicks; Hubbardstown, Wheeler; M. A. C., 9-23-93, Hicks.

Betula.

Hypoxylon multiforme Fr. For Mich. by Miss Minns in Ellis and Everhart, '88 p. 42.

Exosporium cespitosum El. & B. Mackinac Island, July '99, E. T. Harper, reported by Ellis and Bartholomew '02 p. 178.

Betula lutea Michx. f.

Nectria coccinea (Pers.) Fr. Pollock '05 reports from Port Sanilac.

Betula pumila L.

Microsphaera alni (DC.) Wint. Munith, 8-16-93, Hicks.

Alnus.

Diaporthe nivosa E. & Hol. Isle Royale, July '89, N. A. F., 2535.

Erysiphe aggregata (Pk.) Farl. Charlevoix, Spalding, M.

Alnus incana (L.) Willd.

Exoascus amentorum Sadeb. M. A. C., 9-6-85.

Alnus rugosa (Du Roi) Koch.

Microsphaera alni (DC.) Wint. M. A. C., Sept. '93, Hicks.

Erysiphe aggregata Pk. M. A. C., 10-17-93, Hicks; M. A. C., Aug. '93, Hicks.

Taphrina amentorum Sadeb. M. A. C., 10-30-93, Hicks.

FAGACEÆ.

Fagus americana Sweet.

Diatrype albopruinosa (Schw.) Cke. A. A., March, April, *fide* Ellis, M.

Diatrype virescens (Schw.) E. & E. A. A., May 25, Johnson, M.

Dichaena faginea (Pers.) Fr. A. A., May 13, *fide* Ellis, M.

Hypoxylon atropunctatum (Schw.) Cke. A. A., April 22, Johnson, M.

Hypoxylon cohaerens Fr. A. A., April 20, Johnson, M.

Microsphaera alni (DC.) Wint. M. A. C., 9-23-93, Hicks; M. A. C., 10-15-93, Hicks.

Castanea dentata (Marsh) Borkh.

Cytospora. Wayne, March, 1912, Coons, (Not Chestnut Bark Disease *fide* Metcalf).

Melanconis modonia Tul. Colloma, Berrien Co., 9-18-00, Stebbins *fide* Barlow.

Quercus.

Bacterium tumefaciens Smith and Townsend. Pollock '09 p. 54 (Records occurrence and suspects woodpeckers of opening cambium).

Botryosphaeria fuliginosa (Mon.) E. A. A., March, May, Johnson, M.

Calosphaeria barbirostris (Dufour) E. & E. A. A., April, Johnson, M.

Cenangium triangulare Fr. A. A., May 12, *fide* Ellis, M.

Chaetopsis rosella E. & E. A. A., 3-10-94, Johnson, (*cotype*) M.

Dendryphium ellisii Cke. A. A., 9-25-94, Johnson *fide* Ellis, M.

Diaporthe leiphaema (Fr.) Sacc. A. A., April 1, Johnson, M.

Diatrype albopruinosa (Schw.) Cke. A. A., Mich, April, *fide* Ellis, M.

Eutypella spinosa (Pers.) Tul. A. A., April 1, Johnson, M.

Helicoma ambiens Morg. A. A., 5-5-94, Johnson, *fide* Ellis, M.

Helicoma monilipes E. & Johnson. A. A., 5-5-94, Johnson, (*cotype* M.

Helicomyces cinereus Pk. A. A., 6-3-94, Johnson, M.

Helicomyces olivaceus Pk. A. A., April, May, '93, Johnson, M.

Hypoxylon marginatum (Schw.) Berk. A. A., April 28, Johnson, M.

Hypoxylon perforatum (Schw.) Sacc. A. A., April, May, Johnson, M.

Microsphaera alni Wallr. A. A., Sept., Oct., Spalding, M. (*M. quercina*); Grand Rapids, 8-6-90, Smith U. S. D. A., Herb. 1416.

Septonema spilomeum Berk. M. A. C., Oct., '91, Hicks.
Strumella coryneoidea Sacc. & Wint. A. A., 3-2-95, Schaffner and Pieters, M.
Trichoderma lignorum (Tode) Fr. A. A., 4-15-93, Johnson, *fide* Ellis, M.
Valsaria isitira Ces. & DeNot. A. A., March and April, Johnson, M.

Quercus alba L.
Gloeosporium canadense E. & E. Jackson, 6-15-01, *fide* Beal; M. A. C., 7-2-97; M. A. C., 6-11-98; A. A., 7-22-94 Merrow, M. *fide* Wheeler.
Microsphaera alni Wallr. M. A. C., 10-2-91, Hicks. (under name *M. quercina*)
Phyllosticta phomiformis Sacc. A. A., 9-20-93, Pieters, *fide* Ellis; A. A., 1903, *fide* Pollock as a serious Leaf Scorch, M.

Quercus coccinea Wang.
Gloeosporium septorioides Sacc. Battle Creek, August, Spaulding, M.
Marsonia martini Sacc. & Ellis. M. A. C., Sept., '93, Hicks.

Quercus macrocarpa Michx.
Microsphaera alni Wallr. M. A. C., 10-2-92, Hicks. (under name *M. quercina*.)

Quercus rubra var. **ambigua** (Michx.) Fernald.
Macrosporium. Roaring Brook, 8-27-94, Wheeler.

Quercus velutina Lam.
Gloeosporium septorioides Sacc. M. A. C., 8-31-90, Beal. (also at M.)

ULMACEÆ.

Ulmus.
Diaporthe ulmicola E. & E. A. A., April 24, *fide* Johnson, M.
Dothidella ulmi Kleb. M. A. C., Oct., Hicks, (under name of *Dothidea ulmi*); M. A. C. 4-6-12 Coons.
Phleospora ulmi (Fr.) Wallr. Lansing, 9-6-89, Waite, U. S. D. A., Herb. 93.
Uncinula macrospora Pk. M. A. C., Aug., Wheeler; Reported for Mich. by Salmon '00 p. 108.
Valsa ambiens (Pers.) Fr. A. A., March and April, Johnson.

Ulmus americana L.
Calonectria chlorinella (Cke.) E. & E. A. A., Sept. 15, Johnson, M.
Gnomonia ulmea Thüm. M. A. C., Aug., '93, Wheeler; M. A. C., 10-8-86, Beal.
Hypoxylon morsei B. & C. A. A., April 1, *fide* Ellis, M.
Uncinula macrospora Pk. M. A. C., 10-3-91, Wheeler.

Ulmus racemosa Thomas.
Uncinula macrospora Pk. M. A. C., 8-20-91, Hicks.

MORACEÆ.

Toxylon pomiferum Raf.
Sphaeropsis maclurae Cke. M. A. C., 4-1-01, Beal, *fide* Longyear.

Humulus lupulus L.
Cylindrosporium humuli E. & E. Lansing, 9-6-89, Waite, U. S. D. A. Herb. 65.
Phyllosticta humuli major E. & E. A. A., 5-30-94, Merrow, M.

Cannabis sativa L.
Septoria cannabis (Lasch.) Sacc. A. A., July and Oct., Spalding, M.

URTICACEÆ.

Urtica gracilis Ait.

Ramularia urticae Ces. A. A., 6-12-92; Merrow, Econ. Fung. 389; A. A., July, Merrow; Battle Creek, Sept., Spalding, M.

Urticastrum divaricatum (L.) Kuntze.

Phyllactinea corylea (Pers.) Karst. M. A. C., 9-29-92, Hicks.

Adicea pumila (L.) Raf.

Septoria pileae Thüm. 8-16-92, Spalding, M.

POLYGONACEÆ.

Rumex crispus L.

Ramularia decipiens E. & E. A. A., June, Spalding; M. A. C., Sept. Beal, M.; (Two collections by Beal at M. A. C.).

Rumex obtusifolius L.

Ovularia ovata (Fckl.) Sacc. M. A. C., Hicks, 9-11-91.

Ramularia decipiens E. & E. M. A. C., 10-2-90, Beal.

Fagopyrum fagopyrum (L.) Karst.

Ramularia rufomaculans Pk. M. A. C., 9-15-93, Hicks, Fung. Columb. 294.

Polygonum aviculare L.

Erysiphe polygoni DC. M. A. C., 8-31-99, Wheeler.

Polygonum erectum L.

Erysiphe polygoni DC. Lenawee Co., 97 Beal; Three Rivers, 9-12-96, *fide* Coons; Lansing, 9-29-00, Beal.

Polygonum hydropiper L.

Cercospora polygonorum Cke. M. A. C., Aug., '96, Wheeler; M. A. C., Sept., '89, Beal; M. A. C., 9-30-86, Beal.

Septoria polygonicola (Lasch.) Sacc. Battle Creek, 9-3-85, Spalding, M. (also *Helminthosporium*)

Polygonum incarnatum E.

Septoria polygonorum Desm. Byron, 8-25-88, Blount, *fide* Hicks.

Polygonum lapathifolium L.

Septoria polygonorum Desm. A. A., July, Pieters; Battle Creek, Sept., Spalding, M.

Polygonum littorale Link.

Erysiphe polygoni DC. M. A. C., 9-29-00, Beal.

Polygonum pennsylvanicum L.

Septoria polygonorum Desm. M. A. C., 9-15-89; M. A. C., 7-4-91, Baker.

Polygonum persicaria L.

Septoria polygonorum Desm. M. A. C., 7-4-91, Baker, *fide* Hicks.

Polygonum virginianum L.

Phyllactinea corylea (Pers.) Karst. M. A. C., 10-17-91, Hicks.

ARISTOLOCHIACEÆ.

Aristolochia elegans.

Oedema M. A. C., (greenhouse) 4-10-06, (Had been cut back severely.)

CHENOPODIACEÆ.

Chenopodium.

Cercospora dubia (Riess.) Wint. M. A. C., 9-9-91, Hicks.

Chenopodium album L.

Cercospora dubia (Riess.) Wint. Gross Isle, Aug., '85, Campbell, M.

Peronospora effusa Rabenh. A. A., 7-4-92, Merrow, Econ. Fung. 357b; M. A. C., 6-9-11, Bessey; A. A., June, *fide* Spalding, M.

Blitum capitatum L.
Septogloeum atriplicis Desm. M. A. C., '02, Beal; M. A. C., 9-14-93, Hicks.

Beta vulgaris and spp.
Bacterium teutlium Met. Sackett '05 p. 279 (No definite statement of occurrence in Mich.)
Bacterium tumefaciens Smith & Townsend. Reported by Towar, '00 for M. A. C.
Cercospora beticola Sacc. A. A., Aug., Spalding; Battle Creek, Aug., Spalding; M. A. C., Sept., Beal, M.; Reported for Chatham by Wheeler '01; M. A. C., 11-11-91; M. A. C., 8-30-00, Wheeler; Midland, 9-30-01; Paines, Oct., '01, *fide* Beal; M. A. C., 11-4-01, *fide* Hicks; Lansing, 9-5-89, Waite, U. S. D. A., Herb. 49.
Clasterosporium putrifaciens (Fckl.) Sacc. N. Spade, Aug., '99, Wheeler, *fide* Longyear.
Oospora scabies Thaxter. Reported by Towar '00.

AMARANTHACEÆ.

Amaranthus retroflexus L.
Albugo bliti (Biv.) Kuntze. M. A. C., 9-8-91, Beal; M. A. C., 10-3-91, Wheeler; M. A. C., 10-10-91; Hicks, Lansing, 9-5-89, Waite; M. A. C., *fide* Beal. (also at M.)

Acnida tamarascina (Moq.) Uline & Bray.
Albugo bliti (Biv.) Kuntze. M. A. C., 8-1-90.

PORTULACACEÆ.

Portulaca oleracea L.
Albugo portulacae (DC.) Kuntze. M. A. C., 8-16-01, Beal; M. A. C., 8-8-90 Beal; M. A. C., 8-28-01, Hicks. A. A. *fide* Spalding, M.

CARYOPHYLLACEÆ.

Agrostemma githago L.
Marsonia delastrei (DeLacr) Sacc. Battle Creek, 7-6-85, Spalding, M.

Dianthus segnieri.
Cladosporium. M. A. C, 9-4-94, Wheeler, *fide* Beal.

Dianthus caryophyllus L.
Macrosporium nobile Vize. (South Bend, Ind., Oct., '02, Longyear).
Oedema. Kalamazoo, *fide* Beal.
Septoria dianthi Desm. Bay City, 11-29-00, Hedrick; Saginaw, Nov., '00, Longyear; A. A., 10-15-93, Pieters, *fide* Ellis, M.
Volutella dianthi Atk. M. A. C., April, 1912, Coons.

NYMPHAEACEÆ.

Nymphaea.
Cercospora nymphaeacea C. & E. M. A. C., Sept., '97, Wheeler; Pine Lake, 8-6-97, Wheeler; Munith, Aug., '93, Hicks (Fung. Columb. 169.)
Sphaerella pontederiae Pk. A. A., Sept., 18, Johnson, M.

MAGNOLIACEÆ.

Liriodendron tulipifera L.
Mycosphaerella liriodendri Cke. M. A. C., 9-5-91 and 9-28-92, Hicks.

ANONACEÆ.

Asimina triloba (L.) Dunal.
  Phyllosticta asiminae E. & K. M. A. C., 10-10-91, Wheeler.

RANUNCULACEÆ.

Hydrastis canadensis L.
  Alternaria panax Whetzel? South Frankfort, 8-14-08, Vandaman, *fide* Beal.
Coptis trifolia (L.) Salsib.
  Septoria coptidis B. & C. A. A., April, '92, Pieters, M.
  Vermicularia coptina Pk. A. A., May, '92, Pieters, M.
Isopyrum biternatum (Raf.) Tor. & Gray.
  Cercospora merrowi E. & E. A. A., 5-12-94, Merrow, M. (N. A. F. 3195.) (*cotype*).
Actaea rubra (Ait.) Willd.
  Phyllactinea corylea (Pers.) Karst. M. A. C., 10-17-91, Hicks.
  Leptostroma vulgare Fr. (*Leptothyreum vulgare* (Fr.) Sacc.) M. A. C., 5-19-92, Hicks.
Aquilegia canadensis L.
  Septoria aquilegiae Penz. & Sacc. M. A. C., 3-10-91, Beal, (also at M.).
Anemone.
  Sclerotinia tuberosa (Hedw.) Fckl. Macon, Lenawee Co., April 21, Pennington.
Anemone quinquefolia L.
  Plasmopara pygmaea (Unger), Schroet, M.
  Synchytrium anemones (DC.) Wor. May, *fide* Spalding, M.
Anemone canadensis L.
  Phyllosticta anemonis E. & E. A. A., 10-30-93, Merrow, M. (N. A. F. 3152; Fung, Columb. 568). (*cotype*.)
  Plasmopara pygmaea (Unger) Schroet., M. (reported by Kauffman).
Anemone virginiana L.
  Erysiphe polygoni DC. M. A. C., 9-22-89.
  Phleospora anemones E. & K. Grand Ledge, Aug., '91. Beal. (Also at M.)
  Didymaria ungeri Corda *anemones* Holw. M. A. C., 5-20-86, Beal.
Hepatica acuta (Pursh.) Britton.
  Phyllactinia corylea (Pers.) Karst. M. A. C., 10-21-92, Hicks.
  Septoria hepaticae Desm. M. A. C., 5-16-92, Hicks.
Clematis virginiana L.
  Cylindrosporium clematidis E. & E. M. A. C., 9-10-97, Wheeler.
  Erysiphe polygoni DC. Corunna, 10-1-93, Hicks.
Ranunculus acris L.
  Erysiphe polygoni DC., M. A. C., 10-22-91, Hicks.
Ranunculus delphinifolius Torr.
  Erysiphe polygoni DC. M. A. C., 10-28-91, Wheeler.
Ranunculus fascicularis Muhl.
  Peronospora ficariae Tul. A. A., May, *fide* Spalding, M.
Ranunculus recurvatus Poir.
  Ramularia ranunculi Pk. M. A. C., 6-12-95, Wheeler; M. A. C., 5-22-97, *fide* Beal.
Ranunculus repens L.
  Peronospora ficariae Tul. A. A., May, *fide* Spalding, M.

Ranunculus septentrionalis Poir.
Didymaria ungeri Corda. A. A., 5-4-94, Pieters, M.
Thalictrum polygamum Muhl.
Erysiphe polygoni DC. M. A. C., 9-8-86.
Thalictrum purpurascens L.
Erysiphe polygoni DC. M. A. C., 9-2-90, Beal; Park Lake, 9-2-90, Beal and Wheeler; Corunna, 10-1-93, Hicks.
Delphinium spp.
Erysiphe polygoni DC., M. A. C., Beal (three collections.)
Paeonia officinalis L.
Cladosporium paeoniae Pass. M. A. C., May, Wheeler.

BERIBERIDACEÆ.

Berberis vulgaris L.
Fumago vagans Pers. M. A. C., 7-1-91, Beal. (Also at M.)
Podophyllum peltatum L.
Septoria podophyllina Pk. A. A., New Baltimore, Merrow, Johnson, Spalding, M.; M. A. C., 7-4-92, Beal; M. A. C., 6-6-99, Wheeler; M. A. C., 5-6-92, Hicks; M. A. C., 6-8-12, Bessey.

MENISPERMACEÆ.

Menispermum canadense L.
Cercospora menispermi E. & Holw. Battle Creek, Spalding, M.
Microsphaera alni Wallr. A. A., Sept. 23, Johnson, M. (M. menespermi Howe.)
Ramularia contexta E. & E. A. A., Aug., 29, Spalding. (*co-type*) M.
Sphaeropsis menispermi Pk. M. A. C., 4-11-01, Longyear; A. A., 5-24-92, Merrow M.

LAURACEÆ.

Sassafras sassafras (L.) Karst.
Diplodia sassafras Tr. & Earle. A. A., 4-7-95, Johnson, *fide* Ellis, M.; M. A. C., July, '92, Hicks.
Phoma sassafras E. & E. A. A., 4-1-93, Johnson, M.
Phyllactinia corylea (Pers.) Karst. M. A. C., Nov., '92, Hicks.
Benzoin benzoin (L.) Coult.
Epicoccum neglectum Desm. A. A., 9-24-94, Johnson, M.

PAPAVERACEÆ.

Bicuculla canadensis (Goldie) Millsp.
Peronospora corydalis DeBy. May 12, *fide* Merrow, M.; A. A., 5-12-84, Merrow, Economic Fungi Sup. A2.

CRUCIFERÆ.

In general *Plasmodiophora brassica* Wor. is found on members of this family (Eycleshymer '91 p. 87) and *Bacterium campestre* (Pammel) Smith is common on the cultivated plants of the family (Sackett '05 p. 275-278.)
Lepidium virginicum L.
Albugo candida (Pers.) Rouss. M. A. C., Sept., '91, Beal. (Two collections.)
Peronospora parasitica (Pers.) DeBy. A. A., May and June, Merrow, M

Lepidium latifolium.
Albugo candida (Pers.) Rouss. M. A. C., 94, Wheeler; M. A. C., 8-25-99, Wheeler.

Sisymbrium officinale (L.) Scop.
Albugo candida (Pers.) Rouss. M. A. C., 90, Beal; M. A. C., 8-18-91, Hicks.
Septoria sisymbrii E. A. A., 5-22-92, Merrow, M.

Brassica nigra (L.) Koch.
Albugo candida (Pers.) Rouss. M. A. C., 9-16-91, Beal; North Lansing, 9-15-91, Hicks and Wheeler.
Albugo candida (Pers.) Rouss. M. A. C., 9-16-91, Beal; North Lansing, Hicks and Wheeler; North Lansing, 7-1-93, Beal; A. A., May to Oct., *fide* Wheeler and Spalding, M.
Ramularia armoraciae Fckl. A. A., Battle Creek, M. A. C., May, Sept., Nov., Spalding, Pieters, Beal, M.

Brassica oleracea.
Plasmodiophora brassicae Wor. Edwardsburg and Cassopolis, July, 1912, *fide* Coons. (See Eycleshymer 91 p. 79 and Mich. Farmer 4: 13; 136; 148.)
Bacterium campestre (Pam.) Smith. M. A. C., Aug. 12, Coons; Saginaw 8-20-97, *fide* E. F. Smith; Saginaw, 9-2-97, Wheeler.
Sackett, '05 (Smith, 11 p. 300.)

Brassica campestris L.
Macrosporium Brassicae. M. A. C., 8-15-96, Wheeler *fide* Beal; Chatham, 8-27-00, Wheeler (under name *Alternaria* in Wheeler '00.)

Brassica rapa.
Macrosporium (*Alternaria*) *brassicae* (Berk.) Sacc. M. A. C., 6-25-97, C. D. Smith; M. A. C., 8-12-98, Wheeler.

Raphanus sativus.
Albugo candida (Pers.) Rouss. M. A. C., Aug., '90, Beal; M. A. C., 8-28-91, Hicks.
Cladosporium herbarum (Pers.) Lk. M. A. C., 8-7-90, Beal.

Roripa armoracia (L.) Hitchc.
Ramularia armoraciae Fckl. Saginaw, 9-4-89, Waite, U. S. D. A. Herb. 13; M. A. C., 11-11-10; A. A., 7-4-92, Merrow, Econ. Fung. 406; A. A., Battle Creek, M. A. C., May, Sept., Nov., Spalding, Pieters, (Beal, M.)

Roripa palustris (L.) Bess.
Peronospora parasitica (Pers.) DeBy. M. A. C., 10-22-92, Hicks.

Dentaria diphylla Michx.
Albugo candida (Pers.) Rouss. M. A. C., 4-23-98, Wheeler.
Septoria dentariae Pk. Turin, 6-6-01, Barlow, *fide* Beal.

Dentaria laciniata Muhl.
Peronospora parasitica (Pers.) DeBy. May, June, *fide* Merrow, M.

Bursa bursa-pastoris (L.) Britton.
Albugo candida (Pers.) Rouss. M. A. C., 10-9-90, Beal, Econ. Fung. 257b; M. A. C., 5-6-94, Wheeler; Turin, 6-21-01, Barlow; M. A. C., Sept., '91, Hicks.
Peronospora parasitica (Pers.) DeBy. M. A. C., 5-25-12, Taylor.

CAPPARIDACEÆ.

Cleome serrulata Pursh.
Cercospora cleomis E. & E. M. A. C., 8-27-93, Hicks.

RESEDACEÆ.

Reseda odorata.

Cercospora resedae Fckl. M. A. C., Sept. and Aug., '94, Wheeler. (Also at M.)

SARRACENIACEÆ.

Sarracenia purpurea L.

Discosia artocreas (Tode) Fr. A. A., April 28, May 26, Aug. 17, '93, Pieters, Johnson, M.

Mycosphaerella sarraceniae (Schw.) Sacc. M. A. C., April, '94, Hicks; A. A., June, *fide* Johnson, M. (Under name Sphaerella.)

Peckia sarraceniae Peck and Clinton. M. A. C., 8-3-95, Wheeler.

SAXIFRAGACEÆ.

Mitella diphylla L.

Cercospora mitellae Hicks (*Nomena nuda*). M. A. C., April, '90, Hicks. (With *Septoria mitellae.*)

Phyllactinia corylea (Pers.) Karst. M. A. C., Oct., '92, Hicks.

Ramularia mitellae Pk. A. A., 8-4-94, Merrow, M.

Septoria mitellae E. & E. M. A. C., April, '92, Hicks, N. A. F. 2948.

GROSSULARIACEÆ.

Ribes cynosbati L'Her.

Sphaerotheca mors-uvae (Schw.) B. & C. Muskegon, 6-22-98, *fide* Wheeler.

Ribes floridum L'Her.

Haplosporella ribis Sacc. A. A., 4-1-93, Johnson, *fide* Ellis, M.

Ribes nigrum L.

Septoria ribis Desm. South Haven, 9-8-99, Pettit.

Ribes grossularia.

Cercospora angulata Wint. Fennville, July 11, *fide* Coons; see Longyear, '05 p. 383.

Pseudopeziza ribis Kleb. Reported for Mich. especially common Hubbardstown by Smith, '92 p. 374.

Septoria ribis Desm. Chatham, reported by Wheeler, '01.

Sphaerotheca mors-uvae (Schw.) B. & C. M. A. C., 8-3-89, and 7-28-93, Wheeler; Chatham, 8-24-00, Wheeler; (Longyear, '05 p. 385-386, fig. 35; Salmon, '00 p. 71.)

Ribes prostratum L'Her.

Septoria ribis Desm. M. A. C., 9-6-94.

Ribes spp. (Currants).

Cercospora angulata Wint. Longyear, '05 p. 383.

Nectria cinnabarina (Tode.) Fr. Mentioned in Longyear, '05 p. 384, but not reported definitely from Mich. (Also *Pleonectria berolenensis* Sacc.)

Phyllactinia corylea (Pers.) Karst. M. A. C., 10-17-91, Hicks.

Pleonectria berolinensis Sacc. A. A. *fide* Johnson; reported for Mich. by Spalding in Ellis and Evarhart, '86 p. 123.

Pseudopeziza ribis Kleb. Longyear, '05 p. 383 reports for Mich. Lansing, Kalamazoo, May and June, '11 *fide* Coons.

Septoria ribis Desm. Longyear, '05 p. 383, fig. 33 and p. 386; A. A., Battle Creek, M. A. C., Merrow, Spalding, Wheeler, M.

Sphaerotheca mors-uvae (Schw.) B. & C. Longyear '05, p. 385-386, fig. 35.

Ribes.

Sphaerotheca mors-uvae (Schw.) B. & C. A. A., June, *fide* Spalding.

HAMAMELIDACEÆ.

Hamamelis virginiana L.
Glonium lineare (Fr.) Sacc. A. A., April 17, *fide* Johnson, M.
Gonatobotryum maculicolum (Wint.) Sacc. Okemos, 6-15-97, Wheeler, *fide* Beal.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-8-93, Hicks.
Phyllosticta hamamelidis Pk. A. A., June and August, '92, Merrow, Spalding, M.; M. A. C., 10-18-93, *fide* Beal.
Podosphaeria biuncinata Cke. & Pk. Munith, Aug., '93, Hicks; A. A., Aug. 25, *fide* Spalding, M.
Ramularia hamamelidis Pk. M. A. C., 10-8-91, Beal. (Also at M.)
Streptothrix atra B. & C. A. A., April, '93, Johnson, M.

PLATANACEÆ.

Platanus occidentalis L.
Diatrypella prominens (Howe) E. & E. A. A., April 8, *fide* Johnson, M.
Gloeosporium nervisequum (Fckc.) Sacc. M. A. C., 6-20-99, Wheeler, *fide* Beal.
Hendersonia desmazierii Mont. A. A., 4-5-93, Johnson, M.

ROSACEÆ.

Opulaster opulifolius (L.) Kuntze.
Lophiostoma spiraeae Pk. A. A., March 4, *fide* Ellis, M.
Ramularia spiraeae Pk. Grand Ledge, 8-19-94, Wheeler, *fide* Beal.
Sphaerotheca humuli (DC.) Burr. M. A. C., Oct., '91, Wheeler (two collections); Grand Ledge, Aug., '94, Wheeler.

Spiraea salicifolia.
Podosphaera oxyacanthae (DC.) DeBy. Munith, 8-4-93, Hicks.

Spiraea spp.
Sphaerotheca humuli (DC.) Lev. A. A., Oct., *fide* Spalding.

Rubus (Raspberries).
Bacterium tumefaciens Smith and Townsend. Vassar, 6-17-11, Coons; Battle Creek; Temple, Perrington, 5-10-11; Grand Rapids, 7-6-11, *fide* Coons.
Clypeosphaeria hendersoniae (E.) Sacc. A. A., May, *fide* Ellis, M.
Coniothyrium fuckelii. Sacc. (Cane Blight). Longyear, '05 p. 388 and 389, fig. 38; M. A. C.; New Perrington; M. A. C., 7-5-03, Longyear; M. A. C., 1911 and 1912, Coons. (*Leptosphaeria coniothyrium* Sacc.)
Gloeosporium venetum Speg. M. A. C., '92, Beal, M.; Pellston, Detroit, Tawas City, Bad Axe, Portland, *fide* Coons, summer 1911; Longyear, '05 p. 387 (fig. 37) reports for Mich.
Septoria rubi West. A. A., Battle Creek, July, Sept., Johnson, Spalding, M.; Longyear, '05 p. 389, fig. 39, reports for Mich.; M. A. C., Summer '11, *fide* Coons.

Rubus americanus (Pers.) O. A. F.
Sphaerotheca humuli (DC.) Burr. Munith, Aug., '93, Hicks.

Rubus canadensis L.
Septoria rubi West. Munith, Aug., '93; M. A. C., Wheeler, 8-3-95, *fide* Beal.

Rubus hispidus L.
Septoria rubi West. M. A. C., 8-30-90, Wheeler; M. A. C., 6-10-02, Wheeler.

Rubus nigrobaccus Bailey.
Phyllactinia corylea (Pers.) Karst. M. A. C. 10-17-91, Hicks.
Rubus occidentalis L.
Gloeosporium venetum Speg. M. A. C., 90, Beal; M. A. C., 7-1-93, Wheeler.
Rubus strigosus Michx.
Phyllactinia corylea (Pers.) Karst. M. A. C., 19-12-91, Hicks.
Septoria rubi West. M. A. C., 9-24-89, *fide* Beal.
Dalibarda repens L.
Septoria dalibardae Pk. Bellaire, Antrim Co., 94, O. E. Close, *fide* Longyear.
Fragaria virginiana Duchesne and Cult.
Mycosphaerella fragariae (Tul.) Lindau. A. A., May to Aug., Merrow, Spalding, Smith; reported by Longyear, '05, p. 390-391, fig. 40 and by Wheeler, '00 for Chatham; M. A. C., 6-7-86; M. A. C., 6-8-96, Wheeler; Lansing, 11-1-87; M. A. C., 10-13-92, Hicks; Orleans, Adrian, Summer '11, *fide* Coons.
Comarum palustre L.
Sphaerotheca humuli (DC.) Burr. Munith, 8-1-93, Hicks; Park Lake, 10-1-90, Beal.
Potentilla.
Exoascus potentillae Farl. A. A., May, *fide* Ellis, M.
Potentilla monspeliensis L.
Macrosporium, Gloeosporium, South Haven, '97 *fide* Beal.
Peronospora potentillae DeBy. A. A., May, *fide* Spalding, M.
Ramularia arvensis Sacc. A. A., Whitmore Lake, May to Aug., Spalding, Johnson, M.; Whitmore Lake, 6-22-92, Merrow, Econ. Fungi, 280.
Sphaerotheca humuli (D. C.) Burr. M. A. C., 6-25-95, Beal.
Waldsteinia fragarioides (Michx.) Tratt.
Septoria waldsteiniae Pk. & Clint. M. A. C., 9-16-97, Wheeler; M. A. C., 5-18-92, Hicks and Wheeler.
Geum canadense Jacq.
Septoria gei Rob. & Desm. M. A. C., 5-10-92, Hicks.
Geum rivale L.
Sphaerotheca humuli (D. C.) Burr. M. A. C., 9-10-91, Beal.
Agrimonia hirsuta (Muhl.) Bicknell.
Sphaerotheca humuli (D. C.) Burr. M. A. C., 9-24-89; M. A. C., 7-22-92, Hicks.
Rosa (cult.)
Actinonema rosae (Lib.) Fr. M. A. C., 8-8-89; M. A. C., 8-29-94, Wheeler; Detroit, June, '92.
Botrytis vulgaris Fr. A. A., 4-19-05, Pollock, M.
Cercospora rosicola Pass. M. A. C., 8-3-89, *fide* Beal.
Rosa.
Sphaerotheca humuli (D. C.) Burr. M. A. C., Sept., 1911, *fide* Coons; reported for Mich. by Salmon, '00 p. 49.
Sphaerotheca humuli var. *fuliginea* Schlecht. (Salmon, '00 p. 53.)
Sphaerotheca pannosa (Wallr.) Lev. Grosse Isle, 6-26-11, *fide* Coons. (Rambler)
Rosa rubiginosa.
Actinonema rosae (Lib.) Fr. A. A., Aug., '90, Newcombe and Spalding, M.
Rosa rugosa.
Sphaerotheca humuli (D. C.) Burr. M. A. C., 7-25-96, Wheeler.
Sphaerotheca pannosa (Wallr.) Lev. M. A. C., 9-9-97, Wheeler, *fide* Coons

POMACEÆ.

Sorbus americana Marsh.

Diaporthe congesta E. & E. Reported by Ellis and Everhart, '03 p. 165.

Pyrus communis L.

Bacillus amylovorus (Burr.) DeToni. Reported by Longyear, '05 p. 360 and Sackett, '05 p. 269-273, figs. 1-2; Alma, White Cloud, M. A. C., Bay City, Marion, Tustin, South Haven. Arcadia, April to Aug., '11, *fide* Coons.

Fabraea maculata (Lev.) Atk. Longyear, '05 p. 358. (Under name *Entomosporium*.)

Septoria piricola Desm. *Mycosphaerella sentina* (Fckl.) Schroet. A. A., 9-22-92, Pieters; A. A., June, '03, Pollock, M.; reported by Longyear, '05, p. 358, fig. 12, 13.; M. A. C., Sept., '93, Beal; Benton Harbor, 6-30-92, *fide* Hicks; Traverse City, May 11, *fide* Coons.

Venturia pyrina Aderh. Riverside, April, '03, *fide* Longyear; Onondaga, 8-3-99, Longyear; Lansing, 9-6-89, Waite, U. S. D. A. Herb. 51; Leslie, 6-7-98, Longyear; St. Johns, 6-22-94, Wheeler; Cass Co., 8-1-94; M. A. C., 10-15-97, *fide* Wheeler; M. A. C., Summer 1911, Coons; Bering Co., March, 1911, *fide* Coons.

Pyrus japonica.

**Sclerotinia fructigena* (Pers.) Schroet. Reported for Mich. by Pollock, '09 p. 50.

Malus.

Sun Scald. See Longyear, '05 p. 393, fig. 41. Reported for Chatham by Wheeler, '01; M. A. C., Leslie, 1911, *fide* Coons.

Spray Injury. Rochester, 7–94–11, *fide* Coons, (following Lime-Sulphur 1-30).

**Sclerotinia fructigena* (Pers.) Schroet. Pollock, '09 p. 50 for Mich.; see also Pollock, '10 p. 104, 105. (Pome fruits.)

Malus coronaria (L.) Mill.

Venturia pomi (Fr.) Wint. M. A. C., 8-26-92, Wheeler.

Malus malus (L.) Britton.

Fruit Pit. M. A. C., fall 1911, *fide* Coons. (Cause unknown).

Ascochyta mali E. & E. M. A. C., May, '99, Wheeler.

Bacillus amylovorus (Burr) DeToni. Longyear, '05 p. 360; Sackett, '05 p. 269-273, fig. 1-2; Presque Isle, Almont, Grosse Pointe, Grand Rapids, Rochester, Charlevoix, June to Sept., 1911, *fide* Coons.

Bacterium tumefaciens, Smith and Townsend. M. A. C., Fremont, Monroe, Brutus, *fide* Coons.

Cephalothecium roseum Corda. Longyear, '05 p. 362, 363, figs 15, 16.

Cylindrosporium pomi Brooks. Longyear, '05 p. 356 describes the common fruit spot of Baldwins under name of *Phyllachora pomigena* (Schw.) Sacc.; M. A. C., Sept. 11, *fide* Coons; Hillsdale, *fide* Coons.

Glomerella rufomaculans (Berk.) Von Schrenk & Spalding. Longyear, '05 p. 352, 353, fig. 4, 5, reports on Pennocks Red, and Greenings in cellar; M. A. C., 7-26-96, Wheeler; M. A. C., Feb., '92, Beal, M.

Leptothyrium pomi (Mont. & Fr.) Sacc. (Fly Speck.) M. A. C., (arboretum) Dec., '06, *fide* Longyear (on wild apples only). Oakland, Saginaw, Kent, Washtenaw counties, 1912, *fide* Coons.

Alternaria sp. M. A. C., Jan., '03, Loew, *fide* Longyear, (under name of *Macrosporium*. "Not apparent until apple was opened"); Rochester, Mich., 7-24-11, *fide* Coons (following Spray Injury).

*The species of sclerotinia upon fruits in Michigan are not definitely known.

Myxosporium corticolum Edgerton. Pellston, 2-27-12, *fide* Coons, Rochester, Jan., '12, *fide* Coons; M. A. C., April, '12, Coons.

Nummularia discreta Tul. M. A. C., May 11, Coons and Brown, *fide* Coons.

Penicillium glaucum Link. Longyear, '05 p. 350, 361, fig. 14; M. A. C., *fide* Coons.

Phoma ambigua (Nits.) Sacc. *Phoma mali* Schum. & Sacc. Holton, May, '99, *fide* Ellis.

Phyllachora pomigena (Schw.) Sacc. M. A. C., Summer '11, *fide* Coons; Pine Lake, Summer '11, *fide* Coons. (See *Cylindrosporium* above.)

Phyllosticta pirina Sacc. and *limitata* Pk. Longyear, '05 p. 356; South Haven, Sept., '99, Pettit.

Podosphaera leucotrichia (E. & E.) Salmon. Reported by Longyear, '05 p. 356, 375, fig. 25.

Podosphaera oxyacanthae (DC.) DeBy. Whitmore Lake, Aug., '96, Hicks; M. A. C., Summer '11, *fide* Coons. Reported by Longyear, '05, p. 356 and 375.

**Sclerotinia aestivalis* Pollock. Pollock, '09 p. 53; '10, p. 104, (inoculation reported); Palmyra, A. A. Pennington, Pollock, M.

**Sclerotinia fructigina* (Pers.) Schroet. Longyear, '05 p. 350.

Sphaeropsis malorum Pk. A. A., 3-24-93, Johnson. (Under name of *S. mali* (West.) (Sacc.) M. A. C., Johnson, M.; M. A. C., 7-26-01, Wheeler; Longyear, '05 p. 353, 355, figs. 6, 7, 8; Dandeno, 06a p. 40-44, (Physiological experiments); Shelby, Rogers, Empire, Berlamont, Leslie; M. A. C., *fide* Coons.

Venturia pomi (Fr.) Wint. Longyear, '05 p. 349-352, figs. 1, 2, 3; Smith, '92 p. 373-4 reports as excessive in central and southern Mich.; Galloway and Southworth, '89 p. 210 record spraying experiments by Taft at Lansing; reported annually in spraying calendars of Horticultural Department; A. A., M. A. C., June to Sept., Pieters, Smith, Merrow, Spalding, M.; M. A. C., 6-26-97, Beal; Port Huron, 7-27-97, *fide* Beal; M. A. C., 10-2-89, Beal; M. A. C., March, April, 1903, Longyear, (perithecia); M. A. C., Autumn, '03; M. A. C., June, '03, Beal; Summer '11 *fide* Coons.

Aronia nigra (Willd.) Britton.

Cercospora pirina E. & E. Munith, Aug., '93, Hicks; M. A. C., 9-15-93, Hicks.

Amelanchier.

Monilia sp. M. A. C., 5-29-97, Wheeler.

Amelanchier canadensis (L.) Medic.

Dimerosporium collinsii Thüm. Park Lake, 9-23-91, Beal and Hicks; Munith, Aug., '93, Hicks; M. A. C., 6-28-97, Wheeler.

Cydonia vulgaris Pers.

Soft Rot. Longyear, '05 p. 361.

Bacillus amylovorus (Burr.) DeToni. Longyear, '05 p. 360; Sackett, '05 p. 266-273.

Cephalothecium roseum Corda. Longyear, '05 p. 363.

Fabraea maculatum (Lev.) Atk. Longyear, '05 p. 360; M. A. C., 11-4-90, *fide* Hicks; M. A. C., 7-27-93, Wheeler; A. A., Aug., Sept., '87, Spalding, M. (under name *Entomosporium maculatum* var. *cydoniae* C. & E.).

Glomerella rufomaculans (Berk.) Spald. & Von Schrenck. Longyear, '05 p. 361.

Mucor stolonifer Ehr. Longyear, '05 p. 361.

Penicillium glaucum Link. Longyear, '05 p. 361.

*The species of sclerotinia upon fruits in Michigan are not definitely known.

Phoma cydoniae Sacc. & Schulz. Longyear, '05 p. 361.
Podosphaera oxyacanthae (DC.) DeBy. M. A. C., 9-17-93, Hicks.
Sphaeropsis malorum Pk. Longyear, '05 p. 361.

Crataegus.
Cucurbitaria crataegi Schw. A. A., May 10, *fide* Ellis, M.
Fabraea maculatum (Lev.) Atk. M. A. C., Aug., Sept., '06, *fide* Beal (under name *Entomosporium*).
Epicoccum neglectum Desm. A. A., 9-24-94, Johnson, M.
Podosphaera oxyacanthae (DC.) DeBy. Longyear, '05 p. 375.
Monilia (*Sclerotinia*) *linhartiana* Sacc. A. A., April, '94, Pieters, M.
Septoria crataegi Kickx. New Baltimore, 8-13-93, Pieters, M.
Streptothrix atra B. & C. M. A. C., Dec., '91, Hicks; 1-12-92, Hicks.
Valsa ambiens (Pers.) Fr. A. A., March, April, *fide* Johnson, M.

Crataegus coccinea L.
Podosphaera oxyacanthae (DC.) DeBy. M. A. C., 7-4-92, Hicks; M. A. C., 8-20-90, Yoshida; M. A. C., 10-22-92, Hicks.

Crataegus macrantha Lodd.
Cladosporium carpophilum Thüm. M. A. C., '93, Wheeler.

Crataegus punctata Jacq.
Podosphaera oxyacanthae (DC.) DeBy. Okemos, 9-2-91, Hicks.

Craetaegus tomentosa L.
Bacillus amylovorus (Burr.) DeToni. M. A. C., 7-23-95, Wheeler; M. A. C., 6-15-96, *fide* Beal.
Cercospora, Septoria. M. A. C., 8-25-85, *fide* Beal; M. A. C., 9-17-98, Wheeler.

DRUPACEÆ.

Prunus.
Calosphaeria barbirostris (Dufour) E. & E. A. A., April, *fide* Johnson, M.
Cladosporium epiphyllum (Pers.) Mart. Longyear, '05 p. 374 (causing Gummosis).
Cylindrosporium padi Karst. M. A. C., N. Mich. Harrisville, Grand Rapids; Lansing, 9-5-89, Waite U. S. D. A. Herb. 50; Rogers City, Alpena, Marion Island, *fide* Beal; Reported for Chatham by Wheeler, '00.
Dendryphium corticale E. & E. M. A. C., Jan., '92, Hicks. (*cotype*).
Diatrype albopruinosa (Schw.) Cke. M. A. C., Jan., '92, Hicks.
Mucor ambigua Vaill. A. A., March, *fide* Pollock (on old mummies).
Plowrightia morbosa (Schw.) Sacc. A. A., 85, Crosier; A. A., July, '92, Hicks; A. A., *fide* Spalding, M.
Podosphaera oxyacanthae (DC.) DeBy. A. A., Sept., *fide* Spalding.
**Sclerotinia fructigena* (Pers.) Schroet. Pollock, '09, p. 50 reports for Mich.; Pollock, '10 p. 104-105 (stone fruits); Dandeno, '08 p. 51-53 gives records; A. A. Johnson, Spalding, M. (*Monilia*).
Tubercularia sp. Corruna, M. A. C., Hicks.
Valsa leucostoma (Pers.) Fr. A. A., May 12, *fide* Johnson.

Prunus spp. (Plums.)
Gummosis and Canker. North Adams; Spring 12, *fide* Coons; M. A. C., 1912, Coons.
Bacterium pruni Smith. Smith, '11 p. 59 reported for Mich. (1903, Duplain).
Cylindrosporium padi Karst. Longyear, '05 p. 373, fig. 24.
Exoascus sp. M. A. C., 6-23-92, Wheeler (Labelled *E. Pruni* but on leaves and stems only).
Exoascus pruni Fckl. M. A. C., 6-6-97, Wheeler; Longyear, '05 p. 373.

*The species of sclerotinia upon fruits in Michigan are not definitely known.

Plowrightia morbosa (Schw.) Sacc. Longyear, '05 p. 369-371, fig. 21; Dandeno, '07 p. 74-75 reports for M. A. C., (Inoculation experiments made); N. Adams, March, 1912, Corey, *fide* Coons; Eaton Rapids, July 11, *fide* Coons (epidemic); Grand Rapids, June 11, *fide* Coons; Elsie, Clinton Co., 6-1-11, *fide* Coons.

Podosphaera oxyacanthae (DC.) DeBy. Longyear, '05 p. 375, fig. 25.

**Sclerotinia fructigena* (Pers.) Schroet. Longyear, '05 p. 371-373, figs. 22, 23; Dandeno, '08 p. 51-53 for M. A. C.; M. A. C., 8-3-89, (*Monilia*); M. A. C., Manistee, Kalamazoo, Turner, April, May, June, *fide* Coons.

Septoria cerasina Pk. M. A. C., 9-1-83, *fide* Beal.

Prunus (Cherries).

Sun Scorch. Longyear, '05 p. 393.

Cercospora circumscissa Sacc. A. A., 7-18-92, Spalding, M.

Cladosporium carpophilum Thüm. Longyear, '05 p. 367-368, fig. 20.

Cylindrosporium padi Karst. Longyear, '05 p. 375 and 373, fig. 24; Wellston, Holland, Onekama, Tustin, Ludington, Fremont, 1911, *fide* Coons.

Plowrightia morbosa (Schw.) Sacc. St. Ignace, 8-22-03; Longyear, '05 p. 375; M. A. C., *fide* Coons.

Podosphaera oxyacanthae (DC.) DeBy. Marquette, 8-24-98, Towar, *fide* Coons; Longyear, '05 p. 375.

**Sclerotinia fructigena* (Pers.) Schroet. Longyear, '05, p. 371-373, fig. 22, 23; M. A. C., Jackson, June, July, '11, *fide* Coons.

Prunus americana Marsh.

Cladosporium carpophilum Thüm. M. A. C., July, '93, Wheeler.

Exoascus communis Sadeb. Three Rivers, 6-6-90, Wheeler, *fide* Coons.

Exoascus longipes Atk. Grass Lake, 4-31-96, Irwin, *fide* Coons.

Monilia sp. M. A. C., Oct., '91, Hicks.

Plowrightia morbosa (Schw.) Sacc. M. A. C., Dec., '91, Hicks.

Prunus chaemæcerasus Jacq.

Monilia sp. M. A. C., 7-16-93, Wheeler.

Prunus nigra Ait.

Exoascus communis Sadeb. Alma, 6-2-94, Wheeler; Miss Patterson, '94 p. 102 reports a specimen from Alma, Mich. sent her by L. H. Bailey. Atkinson, '94 p. 334 reports material given him by Bailey collected by C. A. Davis at Alma, Mich., 6-2-94. (Probably same material.)

Prunus pumila L.

Exoascus communis Sadeb. Muskegon, June, '98, *fide* Coons.

Monilia. M. A. C., 6-14-93, Wheeler; M. A. C., 7-26-92, Beal; Saugatuck, 8-24-96, Wheeler.

Prunus serotina Ehrh.

Sclerotinia seaveri Rehm. M. A. C., 6-6-93, Wheeler; M. A. C., 6-22-97; M. A. C., 5-29-98; M. A. C., 5-31-00; (under name *Monilia* sp.); M. A. C., 6-1-12, Coons and McClintock, *fide* Coons; Pollock, '09, p. 48-49 records conidial stage, A. A. 5-30-05, and at Dead Lake, '05, Ascus stage was found at A. A., May, '09.

Plowrightia morbosa (Schw.) Sacc. M. A. C., March, '93, Wheeler.

Podosphaera oxyacanthæ (DC.) DeBy. M. A. C., Oct., '91.

Prunus virginiana L.

Exoascus cecidomophilus Atk. Grand Traverse Bay, 7-3-98 *fide* Wheeler.

Exoascus confusus Atk. M. A. C., 6-24-87, *fide* Beal.

*The species of Sclerotinia upon fruits in Michigan are not definitely known.

Monilia. M. A. C., 6-6-94, Wheeler (under name *M. peckiana* Sacc & Vogel).

Plowrightia morbosa (Schw.) Sacc. M. A. C., 5-20-99, Wheeler; Chatham, 8-22-00, Wheeler.

Septoria pruni E. N. Mich., Sept., '90, Beal, M.

Amygdalus persica L.

Gummosis. Northville, Scottsville, South Frankfort, Summer, '11, *fide* Coons.

Little Peach. *The distribution of Little Peach is practically that of yellows, but not so general throughout the area.

Yellows. *Has been found in and south of the following counties: Mason, Newaygo, Montcalm, Clinton, Shiawassee, Livingston, Oakland, Macomb. Is gradually working north. Smith, '88, reported yellows in Berrien Co. since 1866, in Van Buren Co. since '78, in Douglas Co. since 1873, in Ottawa Co. since 1880.

Bacterium tumefaciens Smith & Townsend. Longyear, '05, p. 267 (under name *Dendrophagus globosus* Toumey). Monroe, May 11, *fide* Coons.

Cercospora circumscissa Sacc. Longyear, '05, p. 369. (Not definitely reported).

Cercospora sp. Smith, '92, p. 375, collection by Crozier, A. A.; Douglas and Benton Harbor (diagnosis uncertain).

Cercosporella persica Sacc. Longyear, '05, p. 369 (not definitely reported for Mich.).

Cladosporium carpophilum Thüm. M. A. C., 9-18-91, Beal, M.; Benton Harbor by Smith, '92, p. 374 for Sept., '91; M. A. C., 91, Beal; Constantine, 9-20-00, Barlow; Longyear, '05, p. 367, fig. 20; M. A. C., Summer '11, Coons; Suttons Bay, 6-24-11, *fide* Coons.

Cladosporium epiphyllum (Pers.) Mart. (Gummosis). Saginaw, 5-16-11, *fide* Coons; Longyear, '05, p. 368, fig. 20.

Clubbed Branches. Smith, '91, p. 93, reports for Mich. (terminal bud killed. Mite?).

Wilting of fruit. Smith, '91, p. 94. Benton Harbor, Sept. 22, on Hales Early. (Shrivelled and dropped from trees. Weather?).

Frost crack. Longyear, '05, p. 393 (drupaceous fruits).

Cylindrosporium padi Karst. Longyear, '05, p. 369 (Not definitely reported for Mich.).

Exoascus deformans (Berk.) Fckl. Longyear, '05, p. 365-366, fig. 18, 19; Smith, '90, p. 107 records curl for Central Mich. under name *Taphrina;* Smith, '92 records for S. W. Mich.; Pierce, '00 records many locations, all in western part of state; A. A., June, *fide* Spalding, M.; M. A. C., 6-15-90; M. A. C., 5-14-96, Wheeler; M. A. C., 6-21-98, Beal; Edwardsburg, June, '98, *fide* Wheeler; *coincident with the host.

Helminthosporium carpophilum Lev. Longyear, '05, p. 369 (given as common in '93 on Wager); Constantine, 9-7-94, Beal.

Macrosporium commune Rabh. Longyear, '05, p. 369 (Questionable whether this recorded for Mich.).

Podosphaera oxyacanthae (DC.) DeBy. Longyear, '05, p. 368.

Sclerotinia fructigena (Pers.) Schroet. Smith, '89, p. 123 records for "Peach Belt"; Port Huron, 4-28-11, Dodge, *fide* Coons; Pollock, '09, p. 50; '10, p. 104, 105 records for Mich.; Longyear, '05, p. 371-373, fig. 22, 23 (Gummosis).

*These records are furnished by Prof. L. R. Taft.

Sphaerotheca pannosa (Wallr.) Lev. Smith, '91, p. 90, (Central Mich., common); Longyear, '05, p. 369; South Haven, 7-30-94, Ogden, *fide* Coons.

Valsa leucostoma (Pers.) Fr. A. A. (*Cytospora persicæ* Schw.); A. A., 3-24-93, *fide* Ellis, M.; Newaygo, 6-15-11, *fide* Coons; Whitmore Lake, Aug., '11, *fide* Coons; M. A. C., Spring, '11, *fide* Coons; Longyear, '05, reports on p. 369 *Phoma persicæ* Sacc. (This work is undoubtedly based on Selby's "Constriction Disease)."

Twig Blight and False Winter Killing, probably caused by *Valsa* have been sent in from Kalkaska, Lansing, Detroit.

Amygdalus (Flowering Almond).

Monilia, M. A. C., 6-25-03, *fide* Longyear. (Gummosis)

CAESALPINIACEÆ.

Gleditschia triacanthos L.

Sphaeropsis gleditschiaecola Cke. A. A., April 8, '93, *fide* Johnson, M.

Tubercularia vulgaris Tode (*Nectria cinnabarina*) A. A., 4-8-92, Johnson, M.

PAPILIONACEÆ.

Lupinus sp. (cult.)

Erysiphe polygoni DC. M. A. C., 9-23-93, Hicks.

Lupinus perennis L.

Erysiphe polygoni DC. M. A. C., 10-2-91, Wheeler; M. A. C., 10-10-91, Hicks.

Septogloeum lupini E. & E. Munith, Aug., '93, Hicks. (*cotype*).

Medicago sativa L.

Macrosporium sp. Adrian, 6-22-11, *fide* Coons.

Peronospora trifoliorum De By. M. A. C., Aug., 1911, Bessey; M. A. C., April, 1912, Coons.

Pseudopeziza medicaginis (Lib.) Sacc. M. A. C., 9-8-91, Hicks; M. A. C., 6-10-98; Wheeler; Suttons Bay, M. A. C., Townley, July, Sept., *fide* Coons.

Trifolium pratense L.

Gloeosporium trifolii Pk. M. A. C., 5-31-97, Wheeler; Menominee, July, '99, C. D. Smith, *fide* Wheeler; M. A. C., 7-6-02, Wheeler.

Macrosporium sp. M. A. C., July, '98, Wheeler.

Phyllachora trifolii (Pers.) Fckl. M. A. C., 8-25-83, Beal (under name *Polythrinchium*).

Pseudopeziza trifolii Fckl. M. A. C., 6-26-91, Baker.

Trifolium repens L.

Phyllachora trifolii (Pers.) Fckl. M. A. C., Oct., '85, *fide* Beal; Grosse Isle, A. A., Campbell, Spalding, M. (under name *Polythrinchium trifolii* Kze.).

Robinia.

Cucurbitaria elongata (Fr.) Grev. A. A., May 4, *fide* Ellis, M.

Pseudovalsa profusa (Fr.) De Not. A. A., June 5, *fide* Johnson, M.

Robinia pseudacacia L.

Camarosporium subfenestratum (B. & C.) Sacc. A. A., June, '94, Johnson, M.

Fusarium lateritium Nees. A. A., 6-1-94, Johnson, *fide* Ellis, M.

Meibomia.

Microsphaera diffusa C. & Pk. A. A., Aug., Sept., *fide* Spalding, M.

Meibomia canadense (L.) Kze.
Microsphaera diffusa C. & Pk. Lansing, 9-6-89, Waite U. S. D. A., Herb. 61; A. A., Sept., '93, Pieters; M. A. C., 9-20-94, Wheeler.
Meibomia grandiflorum (Walt.) Kze.
Cercospora desmodii E. & Kellerm. A. A., July, Aug., '90, '92, Spalding, M.
Lespedeza hirta (L.) Ell.
Phyllachora lespedezae (Schw.) Cke. M. A. C., 10-1-90, Beal.
Lespedeza violacea (L.) Pers.
Phyllachora (*Dothidea*) *lespedezae* (Schw.) Cke. M. A. C., 10-11-91, Hicks.
Vicia caroliniana Walt.
Cercospora viciæ E. & H. A. A., 10-13-94, Johnson, M.
Lathyrus.
Macrosporium. M. A. C., 10-28-97, Wheeler.
Lathyrus palustris L.
Microsphaera alni ludens Salmon. M. A. C., Sept., '92, Hicks, *fide* Coons.
Falcata comosa (L.) Kze.
Synchytrium decipiens Farlow. Jonesville, 9-7-83, Beal; M. A. C., 95, Beal; A. A.,? July, *fide* Kauffman, M.
Pisum sativum L.
Ascochyta pisi Lib. M. A. C., 7-6-00, Stebbins, *fide* Wheeler; Lansing Market, 7-5-02, Beal; Kalamazoo, 7-11-11, *fide* Coons.
Cladosporium herbarum (Pers.) Link. M. A. C., Aug., '90.
Erysiphe polygoni DC. Salmon, '00, p. 182, lists for Mich.; Benzonia, 9-2-11, *fide* Coons; M. A. C., 9-15-93, Baker.
Phaseolus vulgaris L.
Colletotrichum lindemuthianum (Sacc. & Magn.) B. & C. M. A. C., 7-6-89, *fide* Beal; (Ruined crop around Lansing in '89); M. A. C., 8-28-91, Hicks; M. A. C., 7-15-01, Wheeler; M. A. C., 8-12-08, Beal; Metamora, Bad Axe, Williamston, Greenville, summer, '11, *fide* Coons.
Fusarium sp. M. A. C., 8-19-01, *fide* A. F. Woods.
Oedocephalum roseum Cke. A. A., 10-23-93, Johnson, M.
Bacterium phaseoli E. F. Smith. Sackett, '05, p. 373-375, figs. 3, 4; M. A. C., Beal. (coextensive with *Colletotrichum*, *fide* Coons).

GERANIACEÆ.

Geranium.
Plasmopara nivea (Ung.) Schroet. var. *geranii* Farlow, *fide* Farlow, M.
Geranium maculatum L.
Sphaerotheca humuli (DC.) Burr. M. A. C., 7-24-92, Hicks.
Pelargonium.
Botrytis vulgaris Pers. A. A., 1-27-94, Johnson, M.
Oedema. Cadillac, 8-1-06, *fide* Beal.

OXALIDACEÆ.

Oxalis.
Microsphaera russelli Clint. A. A., Aug., Nov., *fide* Spalding, M.
Oxalis stricta L.
Microsphaera russelli Clint. Lansing, 9-6-89, Waite; U. S. D. A. Herb. 74, M. A. C., Hicks; Corunna, Oct., '93, Hicks.

RUTACEÆ.

Xanthoxylum americanum Mill.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-3-91, Wheeler; M. A. C., 10-17-91, Hicks; A. A., Oct., '93, Landon, M.
Ptelea trifoliata L.
Alternaria tenuis Nees. A. A., Sept., Pieters, M.

POLYGALACEÆ.

Polygala senega L.
Septoria consocia Pk. A. A., April, '98, Spalding, M.

EUPHORBICEÆ.

Acalypha virginica L.
Cercospora acalyphae Pk. M. A. C., Sept., '85, *fide* Hicks; M. A. C., 9-6-91, Beal (also at M.).
Euphorbia.
Microsphaera euphorbiæ (B. & C.) Pk. Salmon, '00, p. 165; A. A., Battle Creek, Aug., Sept., Spalding, M.
Euphorbia corollata L.
Microsphaera euphorbiae (B. & C.) Pk. M. A. C., 9-6-91, Hicks; 8-31-90; Munith, Aug., '93, Hicks.
Euphorbia nutans Lag.
Fusicladium fasciculatum C. & E. M. A. C., 8-30-93, Wheeler, also at (M.).
Euphorbia serpyllifolia Pers.
Sclerotinia libertiana Fckl. M. A. C., 6-8-11, Coons.

ANACARDIACEÆ.

Rhus.
Botryosphaeria fuliginosa (M. & N.) Ell. A. A., March, May, Johnson, M.
Diaporthe albovelata (B. & C.) Sacc. A. A., Johnson, M.
Diplodia fibriseda (C. & E.) Ell. A. A., 3-18-94, Johnson, M.
Eutypella stellulata (Fr.) Sacc. A. A., May, *fide* Ellis, M.
Macrophoma rhoina (Schw.) Sacc. and *Teichospora rhypodes* E. & E. A. A., Johnson, *fide* Ellis, M.
Rosellinia pulveracea (Ehr.) Fckl. A. A., March, May, *fide* Johnson, M.
Rhus glabra L.
Sphaerothecā humuli (DC.) Burr. Whitmore Lake, Aug.,'96, Hicks.
Rhus toxicodendron L. (including **R. radicans** L. and **R. Rydbergii** Small probably).
Glocosporium toxicodendri E. & M. M. A. C., Hicks.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-13-91, Hicks.
Podosporium rigidum Schw. A. A., Johnson, M.
Septoria toxicodendri Curtis. A. A., July, Aug., Spalding, *fide* Ellis.
Rhus vernix L.
Phyllosticta rhoina Kalchbr. & Cke. Munith, Aug., '93, Hicks.

ILICACEÆ.

Ilex verticillata (L.) Gray.
Ramularia alaterni Thüm. Munith, Aug., '93, Hicks, N. A. F., 3080.
Rhytisma ilicis-canadensis Schw. M. A. C., 9-4-87; Lansing, 9-6-89, Waite; M. A. C., 8-15-94, Wheeler; M. A. C., Oct., '91, Beal, Econ. Fung. 106; M. A. C., 9-6-91; Hicks; Munith, Aug., '93, Hicks.

Ilicioides mucronata (L.) Britton.

Ramularia nemopanthis C. & P. Munith. M. A. C., Aug. '93, Hicks.

Rhytisma ilicis-canadensis Schw. M. A. C., 90, Beal; (under name *R. velatum* S.).

CELASTRACEÆ.

Celastrus scandens L.

Asteridium celastri E. & K. M. A. C., 9-24-89.

Nectria cinnabarina (Tode) Fr. A. A., March, April, *fide* Johnson, M.

Ramularia celastri Pk. Saugatuck, 8-26-96, Wheeler; A. A., Battle Creek, Aug., Sept., Spalding, M.

Tubercularia celastri Schw. A. A., 3-24-93, Johnson, M.

Tubercularia nigricans (Bull.) Link. Corunna, 2-8-92, Hicks.

ACERACEÆ.

Acer.

Leaf Scorch. Longyear, '05, p. 393; Grand Rapids, Aug., 1911, *fide* Coons; M. A. C., Aug., 1911, *fide* Coons.

Diatrype platystoma (Schw.) Berk. A. A., April, *fide* Johnson, M.

Helotium fraternum Pk. Marquette Co., Aug. 23, *fide* Kauffman, M.

Massaria vomitoria B. & C. A. A., May, *fide* Johnson, M.

Phleospora aceris (Lib.) Sacc. M. A. C., Beal, M.

Phyllosticta acericola C. & E. Fennville, 7-6-11, *fide* Coons.

Uncinula circinata C. & Pk. Salmon, '00, p. 106 reports for Mich.; A. A., *fide* Johnson, M.

Acer negundo L.

Leaf Scorch. Grand Rapids, Aug. 11, *fide* Coons.

Macrosporium and *Fusarium*. M. A. C., 9-12-97, Wheeler, *fide* Beal.

Phleospora aceris (Lib.) Sacc. A. A., Sept. 27, *fide* Pieters, M.

Acer nigrum Michx.

Uncinula circinata C. & Pk. M. A. C., 10-8-92, Hicks; M. A. C., '95.

Acer rubrum L.

Galls (Crown Gall?). Norvell, 4-10-13, *fide* Coons; reported for A. A. by Pollock.

Gloeosporium aceris Cke. M. A. C., '92, Hicks.

Phyllosticta acericola C. & E. Munith, Aug., '93, Hicks; A. A., 7-3-93, Newcombe, M.

Rhytisma acerinum (Pers.) Fr. Washtenaw Co., June 3, *fide* Kauffman.

Uncinula circinata C. & Pk. M. A. C., 10-13-91, Hicks and Wheeler. (3 collections.)

Acer saccharum.

Steganosporium piriforme (Hoffm.) Sacc. Grand Rapids, 8-26-11, *fide* Coons.

Acer saccharinum L.

Cytospora leucosperma (Pers.) Fr. A. A., 11-8-93, Miss Langdon, M.

Gloeosporium aceris Cke. M. A. C., 6-2-97, Wheeler.

Phleospora aceris (Lib.) Sacc. Lansing, 9-6-89, Waite, U. S. D. A. Herb. 72; M. A. C., 9-15-89, Beal; M. A. C., Sept. 27, '90.

Phyllactinia corylea (Pers.) Karst. M. A. C., 10-5 and 10-9-92, Hicks.

Rhytisma acerinum (Pers.) Fr. M. A. C., 9-27-93; Rochester, '94, Brotherton; Evart, 10-12-11, *fide* Coons; M. A. C., April, 1912, (asci) *fide* Coons.

Uncinula circinata C. & Pk. M. A. C., Oct., '92, Hicks; M. A. C., 9-23-93, Hicks.

HIPPOCASTANACEÆ.

Aesculus glabra Willd.

Phyllosticta sphaeropsidea E. & E. M. A. C., 8-14-01, Beal; Orion, (data lost).

Aspergillus glaucus Link with *Eurotium herbariorum* (Wigg.) Link. A. A., Pieters, M.

Aesculus hippocastanum L.

Septoria hippocastani B. & B., 10-27-91, Hicks. (also at M.)

Uncinula flexuosa Pk. Washtenaw Co., Oct., *fide* Pollock, M.; Covert, Aug., '93, Atkinson; Whitmore Lake, Aug. '96, Hicks.

BALSAMINACEÆ.

Impatiens.

Mycosphaerella impatiensis Pk. & Clint. A. A., July 3, *fide* Spalding.

Impatiens biflora Walt.

Rhysotheca obducens (Schroet) Wilson. A. A., 5-12-84, Merrow, Econ. Fung. Sup. A7b, May 13, *fide* Kauffman, M.

Septoria nolitangere Gerard. M. A. C., 5-30-86, Beal.

RHAMNACEÆ.

Ceanothus americanus L.

Cercospora. A. A., 9-22-94, Johnson, M.

VITACEÆ.

Vitis.

Bacterium tumefaciens Smith & Townsend. Mt. Morris, 11-20-11, *fide* Coons.

Cladosporium viticolum Ces. (*Cercospora* Sacc.) Longyear, '05, p. 383 "not serious in Mich."

Coniothyrium diplodiella (Speg.) Sacc. Longyear, '05. (Not definitely recorded for Mich.).

Dematophora necatrix Hartig. Longyear, '05, p. 382-383. (Not definitely recorded for Mich.).

Diplodia viticola Desm. A. A., 4-8-93, Johnson, M.

Fusicoccum viticolum Reddick. M. A. C., Jan. 12, and Hickory Corners, Mich., 1912, *fide* Coons).

Glomerella rufomaculans (Berk.) Spald. & Von Schrenck. Longyear, '05, p. 382.

Gonytrichum caesium Nees. A. A., 5-12-93, Johnson, *fide* Ellis, M.

Guignardia bidwelli (Ell.) V. & R. Longyear, '05, p. 376-378, figs. 26, 27; Onondaga, 3-29-03, Longyear; Lansing, St. Joseph, Watervliet, A. A., M. A. C., Hickory Corners, Summer '12, *fide* Coons.

Melanconium fuligineum (Scrib. & Viala) Cav. Longyear, '05, p. 382. (not definitely recorded for Mich.).

Penicillium glaucum Link. Longyear, '05, p. 361.

**Rhysotheca viticola* (B. & C.) Wilson. A. A., 6-29-92, Merrow, Econ. Fungi, 3a; M. A. C., 6-24-90, 8-8-90, Beal; M. A. C., 8-1-93, Wheeler; M. A. C., 9-11-11, Coons; Howell, 6-14-11, *fide* Coons; Longyear, '05, p. 378-380, figs. 28, 29, 30.

Sphaceloma ampelinum De By. M. A. C., Aug., Sept., '93, Wheeler; Longyear, '05, p. 381-382, fig. 32; Charlotte, 7-27-11, *fide* Coons.

Uncinula necator (Schw.) Burr. Longyear, '05, p. 380-382; Salmon, '00, p. 100, lists for Mich.; Smith, '92, p. 373, reports at South Haven; A.

*Plasmopara viticola (B. & C.) Berl & De Toni.

A., Oct., *fide* Spalding, M.; M. A. C., 10-10-91, Hicks; Adrian, 6-22-11, *fide* Coons.

Valsaria insitiva Ces. & De Not. A. A., March and April, *fide* Johnson, M.

Vitis aestivalis Michx.

**Rhysotheca viticola* (B. & C.) Wilson. Sept., '85; M. A. C., 7-14-87; M. A. C., 8-30-90, Wheeler.

Vitis bicolor Le Conte.

**Rhysotheca viticola* (B. & C.) Wilson. M. A. C., 8-30-90, Wheeler; Saugatuck, 8-26-96.

Vitis cordifolia Michx.

Cladosporium viticola Ces. (*Cercospora* Sacc.) M. A. C., Sept., '96, Beal; M. A. C., 8-25-01.

Vitis vulpina L.

Guignardia bidwelli (Ell.) V. & R. M. A. C., Aug., '92, Hicks.

**Rhysotheca viticola* (B. & C.) Wilson. M. A. C., 6-30-97, 10-9-99, Wheeler.

Uncinula necator (Schw.) Burr. M. A. C., 9-21-93, Hicks; Corunna, Sept., '91, Hicks.

Parthenocissus.

Uncinula necator (Schw.) Burr. A. A., Oct., *fide* Spalding, M.

Parthenocissus quinquefolia (L.) Planch.

Cercospora ampelopsidis Pk. M. A. C., 6-22-91, Beal.

Cercospora pustula Cke. M. A. C., Aug. '90, Beal, (also at M.)

Phyllosticta ampelopsidis E. & M. Aug., '90, Beal; M. A. C., 6-22-91; M. A. C., 8-27-93, Hicks; M. A. C., 6-12-03, Longyear; M. A. C., 6-22-91, Beal, M.

Uncinula necator (Schw.) Burr. Constantine, 9-6-94, Beal; Lansing, 10-10-90, Beal.

Parthenocissus tricuspidata (S. & Z.) Planch. (Ampelopsis *veitchii*).

Cercospora ampelopsidis Pk. M. A. C., 8-27-93, Hicks.

TILIACEÆ.

Tilia americana L.

Cercospora microsora Sacc. Lansing, 9-5-89, Waite, U. S. D. A., Herb. 34; A. A., June, July, Spalding, Johnson, M.

Chaetopsis grisea Ehren. A. A., 5-23-95, Johnson, *fide* Ellis.

Exosporium tiliæ Link. A. A., June 3, Johnson, M.

Uncinula clintonii Pk. A. A., Sept., *fide* Johnson, M.; M. A. C., 9-6-90, Toumey; M. A. C., Oct., Sept., 5 collections; Lansing, M. B. Waite, 9-5-89, U. S. D. A., Herb. 35.

MALVACEÆ.

Abutilon.

Chlorosis. Royal Oak, 3-6-11, *fide* Coons.

Althea rosea Cav.

Cercospora althaeina Sacc. A. A., 7-20-92, Merrow, Econ. Fung 461.

Macrosporium. M. A. C., 8-44-94, Wheeler.

Malva rotundifolia L.

Septoria heterochroa Desm. M. A. C., Sept., '91, *fide* Hicks.

Septoria malvicola E. & M. A. A., Battle Creek, Oct., Nov., Johnson, Spalding, M.

Malva sylvestris L.

Macrosporium. M. A. C., Aug., '94, Wheeler, *fide* Beal.

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*Plasmopara viticola (B. & C.) Berl & De Toni.

VIOLACEÆ.

Viola (cult.)
Alternaria violae Gall. & Dors. A. A., *fide* Pollock, '05, p. 56; Lawton, 3-13-12, *fide* Coons; Grand Rapids, 6-4-12, *fide* Coons.

Viola blanda Willd.
Septoria violae West. Munith, Aug., '93, Hicks; (Fung. Columb. 367).

Viola canadensis L.
Septona violae West. M. A. C., 10-27-85, Beal; M. A. C., 10-24-96, Wheeler, *fide* Beal.

Viola cucullata Ait.
Cercospora granuliformis Ell. & Hol. M. A. C., 7-5-92, Hicks.
Vermicularia peckii Sacc. A. A., May, Aug., Merrow, M.

Viola labradorica Schrank.
Phyllactinea corylea (Pers.) Karst. M. A. C., 10-9-92, Hicks.

Viola odorata L.
Cercospora violae Sacc. M. A. C., 10-29-94, Wheeler; M. A. C., 6-10-99.

Viola pubescens Ait.
Septoria violae Westd. A. A., 5-25-94, Johnson, M.

Viola tricolor L.
Cercospora violae Sacc. Lansing, 97, *fide* Beal.

LYTHRACEÆ.

Lythrum salicaria L.
Macrosporium. M. A. C., 10-10-94.

ONAGRACEÆ.

Epilobium coloratum Muhl.
Sphaerotheca humuli (D. C.) Burr. M. A. C., 9-21-93, Hicks.

Onagra biennis (L.) **Scop.**
Septoria oenotherae Westd. M. A. C., 9-15-93, Hicks; M. A. C., 9-23-91, Wheeler; A. A., New Baltimore, Battle Creek, M. A. C., Merrow, Pieters, Spalding, Wheeler, M.

Circaea lutetiana L.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-9-92, Hicks.

ARALIACEÆ.

Aralia hispida Vent.
Cercospora leptosperma Pk. Lansing, 9-6-89, Waite, U. S. D. A., Herb., 111.

Aralia nudicaulis L.
Cercospora leptosperma Pk. Munith, Aug., '93, Hicks.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-17-91, Hicks.

Panax quinquefolia L.
Acrostalagmus sp. (Wilt.) For Mich. by Whetzel and Rosenbaum 12, p. 24, M. A. C., Aug., 1912, *fide* Coons; Eaton Rapids, July, 1912, *fide* Whetzel.
Alternaria panax Whetzel. Woodland, 6-26-09, *fide* Beal; Addison, 8-20-08, Beal; Lansing, Thompsonville, Grawn, Rochester, Edenville, Hope, Eaton Rapids, Tuston, Cassopolis, North Star, Summer, 11, *fide* Coons. For Mich. by Whetzel and Rosenbaum, 1912, p. 10.
Papery Leaf Spot (Drought). Lansing, North Star, Summer, 1911, *fide* Coons; Lakeview, 8-1-06, *fide* Coons.

Phytophthora cactorum (C. & L.) Schr. Reported for Mich. by Whetzel and Rosenbaum, '12, p. 18.; Cassopolis, Eaton Rapids, Spring, '12, *fide* Coons.

Sclerotinia libertiana Fckl. For Mich. by Whetzel and Rosenbaum, '12.

Sclerotinia panacis Rankin. Reported for Portland, Mich. by Rankin, '11 and in Whetzel and Rosenbaum, '12; Cassopolis, Portland, Mich., Summer, '12, *fide* Coons.

Thielavia basicola (B. Br.) Zopf. Eaton Rapids, Cassopolis, July, 1912, *fide* Whetzel and Rosenbaum.

UMBELLIFERÆ.

Daucus carota L.

Cercospora apii Fres. M. A. C., 10-19-01, Beal.

Angelica atropurpurea L.

Fusicladium depressum B. & Br. M. A. C., Oct., '91, Hicks, *fide* Ellis, (also at M.).

Heracleum lanatum Michx.

Ramularia heraclei (Oud.) Sacc. M. A. C., 10-24-94, Wheeler; A. A.,6-8-94, Johnson, M.

Sanicula marylandica L.

Synchytrium pluriannulatum (Curt.) Farl. A. A., 7-12-92, Merrow, Econ. Fung. Sup. A10b; A. A., July, Aug., *fide* Spalding, M.

Apium petroselinum L.

Septoria petroselini Desm. A. A., 1-13-94, Merrow.

Apium graveolens L.

Cercospora apii Fres. For Mich. by Ellis & Evarhart, '85, p. 87, (Spec. sent Farlow by Beal); Jackson, July, '93, Beal, M.; Detroit, 9-14-97; M. A. C., 8-15-02, Beal; M. A. C., 9-22-00, Wheeler; Lansing Market, Fall, '11, *fide* Coons.

Septoria petroselini var. *apii* Br. & Cav. Kalamazoo, 8-29-94, *fide* Coons; M. A. C., Jan., 1911, Bessey, (market)

Pastinaca sativa L.

Cercospora apii Fres. var. *pastinacae* Farl. M. A. C., '01, *fide* Beal.

CORNACEÆ.

Cornus.

Coryneum cornicolum E. & E. M. A. C., 5-20-92, Hicks.

Didymosphaeria epidermidis (Fr.) Fckl. M. A. C., 5-20-92, Hicks.

Myxosporium nitidum B. & C. M. A. C., 1-21-92, Hicks.

Septoria cornicola Desm. A. A., New Baltimore, N. Lansing, Aug. to Oct., Johnson, Spalding, Pieters, Beal, M.

Valsa cornina Pk. A. A., March 28, *fide* Kauffman.

Cornus alternifolia L. f.

Septoria cornicola Desm. Chatham, 8-29-00, Wheeler, *fide* Longyear.

Zythia aurantiaca (Pk.) Sacc. A. A., 5-4-93, Johnson, M.

Cornus candidissima Marsh.

Alternaria M. A. C., 4-12-01, Longyear.

Cornus florida L.

Phyllactinia corylea (Pers.) Karst. M. A. C., Oct., Hicks, 3 collections.

Cornus stolonifera Michx.

Phyllactinia corylea (Pers.) Karst. M. A. C., 10-17-91, Hicks.

Septoria cornicola Desm. N. Lansing, 9-5-90, Beal.

Nyssa sylvatica Marsh.
Phyllosticta nyssae Cke. M. A. C., 8-27-93, Hicks.

ERICACEÆ.

Andromeda glaucophylla Link.
Rhytisma andromedae (Pers.) Fr. M. A. C., 6-19-12, Bessey.
*__Andromeda polifolia__ L.
Rhytisma andromedae (Pers.) Fr. Lansing, 9-6-89, Waite, U. S. D. A., Herb 99; M. A. C., Aug., Sept., Wheeler, Beal, Hicks, (5 collections); Turin, 6-4-01, Barlow.
Chaemedaphne calyculata (L.) Moench.
Ascochyta cassandrae Pk. A. A., 5-27-93, Johnson, M.
Cucurbitatia cassandrae E. & E. A. A., 4-18-93, Johnson, (*Cotype*), M.
Dothichiza cassandrae E. & E. A. A., 4-26-94, Johnson, (*Cotype*), M.
Venturia pulchella C. & P. M. A. C., 10-15-92, Hicks.
Gaultheria procumbens L.
Asterina gaultheriae Curtis. M. A. C., 9-22-97, Wheeler.

VACCINIACEÆ.

Gaylussacia resinosa (Ait.) Torrey and Gray.
Microsphaera alni vaccinii (Schw.) Munith, 8-12-93, Hicks; Jackson Co., 8-4-99, Longyear.
Vaccinium.
Sclerotinia sp. Longyear, '02, p. 61-62, Pl. II.
Vaccinium corymbosum L.
Microsphaera alni vaccinii Schw. M. A. C., Oct., '92, Hicks.
Ramularia vaccinii E. & Pk. (?) Munith, Aug. '93, Hicks.
Sclerotinia vaccinii Wor. M. A. C., Sept., '94, Wheeler; M. A. C., 7-8-99, Longyear (both *fide* Longyear).
Septoria difformis C. & Pk. M. A. C., 8-15-94, Wheeler.
Vaccinium pennsylvanicum Lam.
Microsphaera alni vaccinii Schw. Munith, Aug., '93, Hicks.
Oxycoccus oxycoccus (L.) Mac. M.
Phoma vaccinii E. & E. A. A., 4-18-93, Johnson (*cotype*), M.
Ramularia multiplex Pk. M. A. C., 7-26-90, Beal. (also at M.)

PRIMULACEÆ.

Steironema ciliatum (L.) Raf.
Septoria conspicua E. & Mart. A. A., Merrow & Spalding; New Baltimore, Pieters; Park Lake, Beal and Wheeler; M. A. C., Hicks; July to Sept., M. (also at M. A. C.).
Septoria lysimachiae Ell. & Halst. New Baltimore, 8-13-93, Pieters, M.
Trientalis americana (Pers.) Pursh.
Septocylindrium magnusianum Sacc. Munith, Aug., '93, Hicks, N. A. F. 3082.
Septoria increscens Pk. Munith, Aug. '93, Hicks.

OLEACEÆ.

Syringa vulgaris L.
Microsphaera alni Wallr. Okemos, 9-3-91; M. A. C., Summer, '11, *fide* Coons.

*Probably many of the collection ascribed to this host really belong to the preceding species.

Fraxinus.
Gloeosporium aridum E. & Holw. A. A., 4-23-94, Johnson, M.
Hysterographium fraxini (Pers.) De Not. M. A. C., Dec., '91, Hicks.
Phyllactinia corylea (Pers.) Karst. A. A., Sept., Oct., Pieters, M.; Lansing, 9-6-89, Waite, U. S. D. A., Herb. 70.
Phyllosticta fraxinicola Curr. Battle Creek, 9-12-85, Spalding, M.
Fraxinus americana L.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-7-86; M. A. C., 10-10-91 Hicks.
Septoria fraxini Westd. M. A. C., 9-2-97, Wheeler.
Sphaerographium fraxini (Pk.) Sacc. M. A. C., 2-3-92, Hicks.
Fraxinus lanceolata Borck.
Cylindrosporium fraxini E. & E. M. A. C., 9-9-90, Beal. (also at M.)
Fraxinus nigra Marsh.
Phyllactinia corylea (Pers.) Karst. M. A. C., Sept. and Oct., Hicks and Wheeler; Lansing, 9-5-89, Waite, U. S. D. A., Herb. 44.
Septoria fraxini Desm. M. A. C., 9-24-89, Beal.
Fraxinus pennsylvanica Marsh.
Gloeosporium fraxineum (Pk.) M. A. C., 6-2-97, Wheeler.
Phyllactinia corylea (Pers.) Karst. M. A. C., 9-22-91, Beal, Econ. Fung. 143.
Piggotia fraxini B. & C. M. A. C., 10-7-89, *fide* Beal.
Fraxinus quadrangulata Michx.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-9-92, Hicks.

MENYANTHACEÆ.

Menyanthes trifoliata L.
Physoderma menyanthis De By. June, *fide* Johnson, M.

APOCYNCEÆ.

Apocynum.
Didymosphaeria epidermidis var. *herbeola* E. & E. A. A., Johnson, (*co-type*), M.
Apocynum androsaemifolium L.
Gloeosporium apocyni Pk. M. A. C., 7-19-02, *fide* Beal.
Septoria littorea Sacc. A. A., 9-22-94, Johnson M.
Apocynum cannabinum L.
Cercospora apocyni E. & K. N. Lansing, Grand Ledge, Sept., '90, Beal, Dewey, M. (also M. A. C.).

ASCLEPIADACEÆ.

Asclepias.
Vermicularia compacta C. & E. A. A., April, '93, Johnson, M.
Asclepias syriaca L.
Alternaria tenuis Nees. A. A., Sept., Johnson, M.
Cercospora clavata (Ger.) Pk. A. A., July, '85, Campbell; Grosse Isle, Aug., '92, Spalding, M.; Lansing, 9-6-89, Waite, U. S. D. A., Herb. 68.
Scolecotrichum asclepiadis E. & E. M. A. C., 8-21-94, Wheeler, *fide* Beal.
Phyllosticta cornuti E. & K. M. A. C., 9-24-89, Beal.
Asclepias incarnata L.
Cercospora asclepiadis Ell. Lansing, 10-5-98, Beal; Oct., '90, *fide* Beal.

CONVOLVULACEÆ.

Convolvulus sepium L.
Septoria convolvuli Desm. North Lansing, 9-27-90, Beal. (also at M.)
Septoria flagellaris E. & E. Battle Creek, 9-8-85.
Ipomoea pandurata (L.) Meyer.
Albugo ipomoeae-panduratae (Schw.) Swing. M. A. C., 7-3-01, Beal.

POLEMONIACEÆ.

Phlox divaricata L.
Cercospora omphacodes E. & Holw. M. A. C., 7-29-04, Beal.
Septoria divaricatae E. &. E. A. A., 4-20-94, Pieters, *fide* Ellis, M.
Phlox drummondii Hook.
Septoria drummondii E. & E. M. A. C., Sept., '01, Wheeler.
Phlox paniculata L.
Erysiphe cichoracearum DC. M. A. C., 9-26-86, *fide* Coons.

HYDROPHYLLACEÆ.

Hydrophyllum virginicum L.
Erysiphe cicheracearum DC. M. A. C., 6-19-86.

BORAGINACEÆ.

Lappula virginiana (L.) Greene.
Erysiphe cichoracearum DC. M. A. C., 9-5-94, Wheeler.
Myosotis virginica (L.) B. S. P.
Peronospora myosotidis De By. A. A., 5-26-84, Merrow, Econ. Fung. Sup. 6a.; A. A., May, June, *fide* Johnson, M.

VERBENACEÆ.

Verbena aubletia L. (cult.)
Erysiphe cichoracearum DC. M. A. C., 8-20-94, Wheeler.
Verbena hastata L.
Erysiphe cichoracearum DC., M. A. C., 10-2-91, Hicks.
Verbena hastata L. and **urticifolia** L.
Septoria verbenae Rabh. & Desm. A. A., June, July, Merrow, Johnson, M.
Verbena urticifolia L.
Erysiphe cichoracearum DC. M. A. C., 10-5-90, Beal.

LABIATÆ.

Scutellaria.
Erysiphe galeopsidis DC. Lansing, Aug., Sept., *fide* Johnson, M.
Scutellaria galericulata L.
Erysiphe galeopsidis DC. M. A. C., 10-11-92, Hicks.
Scutellaria lateriflora L.
Erysiphe galeopsidis DC. M. A. C., Sept., Oct., Beal and Hicks; Turin, 8-21-01, Barlow.
Septoria scutellariae Thüm. M. A. C., 10-3-91, Hicks, M.
Stachys sp.
Erysiphe galeopsidis DC. Saginaw, 9-4-89, Waite, U. S. D. A., Herb. S.
Stachys tennifolia Willd.
Erysiphe galeopsidis DC. M. A. C., 9-28-91, Wheeler.

SOLANACEÆ.

Physalis.

Cercospora physalidis E. Saugatuck, 8-30-96, Wheeler; M. A. C., 9-4-96, Wheeler.

Physalis heterophylla nyctaginea (Dunal) Rydb.

Macrosporium. M. A. C., 9-24-89.

Solanum dulcamara L.

Ramularia dulcamarae Pk. A. A., 10-10-94, Johnson, M.

Solanum jamesii Torr.

Macrosporium. M. A. C., 8-29-94.

Solanum sp.

Ophiobolus porphyrogonus (Tode) Sacc. A. A., Sept. 20, *fide* Johnson, M.

Solanum tuberosum L.

Bacterium solanacearum E. F. Smith. Sackett, '05, p. 280, (no definite statement of occurrence in Mich.).

Cladosporium fulvum Cke. M. A. C., 8-9-98, Wheeler, *fide* Beal.

Fusarium (Dry Rot). A. A., 2-13-11, Coons; M. A. C., Summer, '11, Alden, Spring, '12, *fide* Coons, Smith and Swingle, '04, pp. 10, 11.

Internal Brown Spot. M. A. C., Spring, 1912, Coons.

Macrosporium solani E. & M. Chatham, 8-25-00, Wheeler; M. A. C., 8-16-01, Beal; M. A. C., 10-14-11, Coons; Chatham, see Wheeler, '00.

Oospora scabies Thaxter? (scab.) M. A. C. Summer, 1911. Coons.

Phytophthora infestans (M.) De By. M.; M. A. C., '00, *fide* Beal; Cassopolis, 1912, *fide* Coons.

Rhizoctonia sp. (*Hypochnus solani* Prill. and Delacr.) (*Corticium vagum solani* Burt.) M. A. C., 1911, 1912, Coons.

Stysanus stemonites (Pers.) Corda. A. A., '03, Pollock, M.

Tip Burn, M. A. C., *fide* Eustace.

Lycopersicon lycopersicon (L.) Karst.

Oedema. M. A. C., (greenhouse) 2-18-95, Hedrick (excessive water); M. A. C., Aug., Sept., Beal and Wheeler.

Septoria lycopersici Speg. M. A. C., Summer, '11, *fide* Coons.; S. S. Marie, 8-3-09.

Fruit Rots—*Alternaria, Colletotrichum, Fusarium,* etc., Summer, 1911, *fide* Coons.

Datura inermis Jacq.

Macrosporium cookei Sacc.? M. A. C., 10-10-02, Beal.

Datura tatula L.

Macrosporium cookei Sacc.? M. A. C., 10-10-02, Beal; M. A. C., 9-12-11, Bessey (under name *M. solani* E. & M.).

SCROPHULARIACEÆ.

Verbascum.

Lophiostoma caulium (Fr.) De Not. A. A., April 15, Johnson, M.

Verbascum thapsus L.

Ramularia variabilis Fckl. Lansing, 9-5-89, Waite, U. S. D. A., Herb. 31. A. A., Battle Creek, June, July, Merrow, Johnson, Spalding, M.

Linaria linaria (L.) Karst.

Macrosporium. M. A. C., 9-22-89, Beal.

Scrophularia marylandica L.

Septoria scrophulariae Pk. A. A., Battle Creek, July, Sept., Merrow, Spalding, M.; Hubbardstown, Wheeler; M. A. C. Sept., '91, Hicks.

Chelone glabra L.

Erysiphe galeopsidis DC. M. A. C., 10-3-90, Hicks; M. A. C., Sept., '85, Beal; Lansing, Aug. to Sept., *fide* Johnson, M.

Erysiphe polygoni DC. M. A. C., 10-3-91, Hicks, (under name *E. communis* Wallr.).

Septoria wilsoni Clinton. M. A. C., 9-11-96, Beal.

Pentstemon digitalis (Sweet.) Nutt.

Septoria pentastemonis E. & E. M. A. C., 9-16-97, Wheeler.

Veronica arvensis L.

Septoria veronicae Rob. A. A., 5-21-94, Pieters, M. (*S. veronicae* Desm.?).

Leptandra virginica (L.) Nutt.

Sphaerotheca humuli (DC.) Burr. Lansing, 9-6-89, Waite, U. S. D. A., Herb. 71 (*S. castagnei*); M. A. C., Sept., Hicks.

Pedicularis lanceolata Michx.

Sphaerotheca humuli (DC.) Burr. Lansing, 9-6-89, Waite, U. S. D. A., Herb., 75, (*S. castagnei*); M. A. C., Sept., Oct., Beal, Hicks.

BIGNONIACEÆ.

Catalpa.

Macrosporium catalpae E. & M. M. A. C., 9-5-01, *fide* Beal.

PLANTAGINACEÆ.

Plantago major L.

Peronospora alta Fckl. A. A., Aug., *fide* Spalding, M.

Ramularia plantaginis E. & M. A. A., Battle Creek, May, July, Spalding, Johnson, M.; M. A. C., Oct., Nov., *fide* Beal.

Rhabdospora continua (B. & C.) Sacc. A. A., 5-11-93, Johnson, M.

RUBIACEÆ.

Galium circaezans Michx.

Phyllactinia corylea (Pers.) Karst. M. A. C., '92, Hicks.

Septoria psilostega E. & M. A. A., June, '94, M.; M. A. C., 6-11-99, Beal.

Galium lanceolatum Torr.

Phyllactinia corylea (Pers.) Karst. M. A. C., 10-9-92, Hicks.

CAPRIFOLIACEÆ.

Sambucus.

Diaporthe spiculosa (A. & S.) Nitsc. A. A., April 1, *fide* Johnson, M.

Diplodia sambucina Sacc. A. A., 4-26-94, Johnson, M.

Dothiorella macrospora B. & C. A. A., 4-8-93, Johnson, *fide* Ellis, M.

Sphaeropsis sambuci Pk. A. A., 3-31-93, Johnson, M.

Sambucus canadensis L.

Microsphaera grossulariae (Wallr.) Lev. M. A. C., 9-15-95, Hicks.

Phyllactinia corylea (Pers.) Karst. M. A. C., 10-10-92, Hicks.

Septoria sambucina Pk. Lansing, 9-6-89, Waite, U. S. D. A., Herb., 84; M. A. C., Hicks.

Tubercularia sambuci Corda. M. A. C., 2-3-92, Hicks.

Viburnum acerifolium L.

Cercospora varia Pk. Grand Ledge, 8-1-91, Beal, (also at M.)

Viburnum alnifolium Marsh.

Microsphaera alni Wallr. N. Lansing, July, '92, Hicks.

Viburnum lentago L.

Microsphaera alni Wallr.. M. A. C., 9-27-90, Beal.

Viburnum pubescens (Ait.) Pursh.
Microsphaera alni Wallr. M. A. C., 10-12-92, Hicks.
Triosteum perfoliatum L.
Phyllactinia corylea (Pers.) Karst. M. A. C., 10-17-91, Hicks.
Symphoricarpos symphoricarpos (L.) Mac. M.
Microsphaera symphoricarpi Howe. Washtenaw Co., Sept., *fide* Pollock, M
Lonicera.
Lophiostoma caulinum (Fr.) De Not. A. A., April 15, *fide* Johnson. M.
Rhabdospora lonicerae (C. & E.) Sacc. A. A., 4-17-93, Johnson, *fide* Ellis, M.
Lonicera dioica L.
Microsphaera alni Wallr.. M. A. C., Sept., Oct., '90, Hicks.

VALERIANACEÆ.

Valeriana officinalis L.
Ramularia valerianae (Speg.) Sacc. M. A. C., Sept., '95, Beal.

DIPSACACEÆ.

Dipsacus.
Cercospora elongata Pk. M. A. C., 9-16-97, Wheeler; A. A., 8-8-94, Merrow, M.

CUCURBITACEÆ.

Micrampelis lobata (Michx.) Greene.
Cercospora. Battle Creek, 9-8-85, Spalding, M.
Septoria sicyi Pk. A. A., 4-28-93, 5-11-95, Johnson, M.
Cucurbits in general.
Macrosporium. Smith, '92, p. 373, reports this as a new disease for Mich.
Alternaria brassicae nigricans Pegl. Portland, July 29, Beal; M. A. C., 8-4-00, Wheeler; Sibley, 7-6-11, *fide* Coons.
Bacillus tracheiphilus Smith. Sackett, '05, p. 278-279, records presence at M. A. C. and throughout state; Smith, '11, p. 209 reports for Mich., p. 211 reports for Hubbardston; Saginaw, Grand Rapids.
Colletotrichum lagenarium (Pers.) E. & Halst. Grand Rapids, 6-6-06, *fide* Longyear; M. A. C., Oct., '94, *fide* Beal.
Cladosporium cucumerinum E. & Arth. M. A. C., Summer, '11, *fide* Coons.
Fusarium. M. A. C., Summer, '11, *fide* Coons.

CAMPANULACEÆ.

Lobelia.
Septoria lobeliae Pk. M. A. C., 8-6-89; M. A. C., Oct., '91, Hicks; M. A. C., 9-16-97, Wheeler.

CICHORIACEÆ.

Tragopogon porrifolius L.
Albugo tragopogonis (DC.) S. F. Gray. M. A. C., Aug., Oct., '02, Beal, Longyear.
Taraxacum sp.
Sphaerotheca humuli fuliginea Schlecht. Saginaw, 9-4-89, Waite, U. S. D. A., Herb. 23; M. A. C., 9-20-93, Baker; M. A. C., Aug., Oct., Hicks.
Taraxacum taraxacum (L.) Karst.
Ramularia taraxaci Karst. M. A. C., 6-6-94, Wheeler; A. A., M. A. C., May, Sept., Merrow, Beal, M.

Taraxacum erythrospermum Andz.
Ramularia taraxaci Karst. M. A. C., May, 1912, Bessey.
Lactuca.
Sphaerella lactucae E. & K. Park Lake, Sept., *fide* Beal.
Lactuca canadensis L.
Erysiphe cichoracearum DC. M. A. C., 9-8-86, Beal.
Lactuca sativa L.
Erysiphe cichoracearum DC. M. A. C., 90, Beal.
Marsonia perforans E. & E. Grand Rapids, 3-20-97, Longyear; M. A. C., 12-20-02, Longyear; Davison, 7-2-03, *fide* Longyear; Dandeno, '06, p. 45-47, for W. Mich. (under name *Didymaria*).
Sclerotinia fuckeliana De By. E. Grand Rapids, Jan. 11, *fide* Coons.
Septoria consimilis E. & M. M. A. C., 8-23-01, Beal.
Septoria lactucae Pass. A. A., M. A. C., Aug., Merrow, Beal, M.; M. A. C., 8-3-89, 9-8-90, Beal.
Lactuca spicata (Lam.) Hitchcock.
Bremia lactucae Regel. June, Aug., Spalding, M.
Sphaerotheca humuli fuliginea Schlecht. M. A. C., 9-10-90, Yoshida.
Lactuca virosa L.
Septoria lactucicola E. & M. Munith, Aug., '92, Hicks.
Nabalus.
Septoria nabali B. & C. M. A. C., 6-10-98, Wheeler.
Sphaerotheca humuli (DC.) Burr. North Lansing, 9-16-91, Hicks.

AMBROSIACEÆ.

Ambrosia artemisiaefolia L.
Albugo tragopogonis (DC.) S. F. Gray. A. A., *fide* Merrow, M.
Erysiphe cichoracearum DC. M. A. C., 9-28-86, Beal.
Ambrosia trifida L.
Erysiphe cichoracearum DC. M. A. C., (no other data); Saginaw, 9-4-89, Waite, U. S. D. A., Herb. 4.
Xanthium canadense Mill.
Erysiphe cichoracearum DC. M. A. C., Sept., Beal, Hicks.
Xanthium glabratum (DC.) Britton.
Erysiphe cichoracearum DC. M. A. C., 9-15-89, Beal.

COMPOSITÆ.

Vernonia noveboracensis (L.) Willd.
Erysiphe cichoracearum DC. M. A. C., 10-2-93, Hicks.
Eupatorium perfoliatum L.
Cercospora perfoliati E. & E. M. A. C., 9-28-92, Hicks.
Erysiphe cichoracearum DC. M. A. C., Sept., '93, Hicks.
Eupatorium purpureum L.
Erysiphe cichoracearum DC. M. A. C., 9-26-93, Baker, M. (also by Hicks).
Rhysotheca halstedii (Farl.) Wilson. A. A., 6-23-92, Merrow, Econ. Fung. 313; A. A., July, Sept., *fide* Spalding, M.
Ageratum mexicanum Sims.
Fumago vagans Pers. M. A. C., 4-20-94, Wheeler.
Lacinaria scariosa (L.) Hill.
Helminthosporium macrocarpum. Grev. M. A. C., '83.
Solidago.
Leptostroma vulgare. M. A. C., 5-20-92, Hicks.

Macrosporium. Au Sable, 10-5-89, *fide* Beal.
Rhabdospora subgrisea Pk. A. A., 4-4-93, Johnson, *fide* Peck, M.

Solidago canadensis L.
Erysiphe cichoracearum DC. M. A. C., 9-3-92, Hicks; N. Lansing, 10-5-90 Beal.
Septoria solidaginicola Pk. A. A., 6-23-94, Pieters M.

Solidago patula Michx.
Septoria dolichospora E. & E. N. Lansing, 10-5-90, Beal.

Euthamia graminifolia (L.) Nutt.
Rhytisma solidaginis Schw. (insect work!). Port Huron, 7-6-93, Dodge; M. A. C., 7-29-91, Baker.

Callistephus hortensis Cass.
Fusarium. Grand Rapids, Aug., '98, *fide* Beal.

Aster.
Macrosporium. M. A. C., Oct., '93, Beal.

Aster cordifolius L.
Septoria astericola E. & E. M. A. C., '92, Hicks.

Aster macrophyllus L.
Septoria atropurpurea Pk. A. A., July, '92, Spalding, M.

Aster novae-angliæ L.
Ramularia macrospora var. *asteris* Trel. Whitmore, 6-26-95, Merrow, M.

Aster puniceus L.
Erysiphe cichoracearum DC. M. A. C., Oct., Beal, Hicks.

Aster umbellatus Mill.
Erysiphe cichoracearum DC. M. A. C., Sept., '93, Hicks.

Erigeron.
Cercospora cana Sacc. A. A., June, Aug., Merrow, M.
Septoria erigerontis B. & C. M. A. C., Sept., Aug., Beal, Wheeler, Hicks.

Erigeron annuus (L.) Pers.
Septoria erigerontis B. & C.? (*erigerontea* Pk.?) A. A., 6-7-93, Pieters, M.
Sphaerotheca humuli fuliginea Schlecht. Corunna, Oct., '93, Hicks.

Leptilon canadensis (L.) Britton.
Cercospora cana Sacc. M. A. C., 8-27-93, Hicks.
Cercospora grisella Pk. Battle Creek, 7-4-85, Spalding, M.

Gnaphalium uliginosum L.
Macrosporium commune Rab. (?) M. A. C., 9-39-97, Wheeler.

Inula helenium L.
Ramularia sp. Saginaw, 9-4-89, Waite, U. S. D. A., Herb. 25.

Silphium perfoliatum L.
Cladosporium herbarum Lk. M. A. C., 9-7-91, Beal.

Rudbeckia laciniata L.
Ramularia rudbeckiae Pk. Lansing, 9-5-89, Waite, U. S. D. A., Herb., 32, 66; M. A. C., Aug., Sept., Beal, Wheeler, Hicks; A. A., M. A. C., May, Nov., Johnson, Beal, M.

Ratibida pinnata (Vent.) Barnhart.
Septoria infuscata Wint. A. A., 7-18-87, Spalding, M.

Helianthus.
Leptosphaeria doliolum (Pers.) Ces. & De Not. April 28, *fide* Johnson, M.
Leptosphaeria subconica (C. and P.) Sacc. A. A., May 15, *fide* Johnson, M.
Leptothyrium vulgare (Fr.) Sacc. A. A., 5-4-93, Johnson, M.
Vermicularia subglabra Ck. & Hark. A. A., May, '94, Johnson, M.

Helianthus giganteus L.
Erysiphe cichoracearum DC. Park Lake, 9-23-91, Beal.

Helianthus orgyalis DC.
Erysiphe cichoracearum DC. M. A. C., 10-31-91, Hicks.
Helianthus petiolaris Nutt.
Erysiphe cichoracearum DC. M. A. C., 9-22-93, Hicks.
Biedens frondosa L.
Cercospora umbrata Ell. & Holw. Saginaw, 9-4-89, Waite, U. S. D. A., Herb. 19.
Rhysotheca halstedii (Farl.) Wilson. A. A., 7-23-92, Merrow, Econ. Fung. 298.
Sphaerotheca humuli fuliginea Schlecht. M. A. C., Sept., Wheeler, Hicks, Baker.
Bidens trichosperma tenuiloba (Gray) Britton.
Sphaerotheca humuli fuliginea Schlecht. Munith, 8-11-93, Hicks.
Chrysanthemum sinense Sab.
Cylindrosporium chrysanthemi Ell. & Dear. M. A. C., 12-2-01, Beal.
Erechtites hieracifolia (L.) Raf.
Sphaerotheca humuli fuliginea Schlecht. M. A. C., 10-12-91.
Mesadenia atriplicifolia (L.) Raf.
Septoria cacaliae E. & K. M. A. C., 8-27-93, Hicks.
Arctium lappa L.
Septoria lapparum Sacc. M. A. C., 10-2-90, Beal. (also at M.)
Carduus.
Ophiobolus acuminatus (Sow.) Duby. April 28, *fide* Johnson, M.
Carduus muticus (Michx.) Pers.
Septoria cirsii Niessl. A. A., 11-11-93, Johnson, M.
Carduus altissimus L.
Albugo tragopogonis (DC.) S. F. Gray, M. A. C., 9-8-92.
Erysiphe cichoracearum DC. M. A. C., Sept., Hicks.
Carduus arvensis (L.) Robs.
Albugo tragopogonis (DC.) S. F. Gray. M. A. C., 7-13-93, *fide* Hicks.
Carduus discolor (Muhl.) Nutt.
Erysiphe cichoracearum DC. Harrison. Sept., 90, Beal.
Carduus muticus (Michx.) Pers.
Albugo tragopogonis (DC.) S. F. Gray. M. A. C., 9-8-92; Chatham, 8-22-00, Wheeler.
Erysiphe cichoracearun DC. M. A. C., Sept., Oct., 91, Hicks.
Septoria cirsii Niessl. A. A., 11-11-93, Johnson, M.
Dahlia variabilis Desp.
Mycosphaerella dahliae C. & E. M. A. C., 8-20-94, Wheeler.
Zinnia.
Alternaria. M. A. C., 8-19-02, Beal.

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Bur. Plant Ind. 250: 1-44, 12 Pls. and 5 figs.
Wilson, G. W., 1907:
Studies in North American Peronosporales.
Bul. Tor. Bot. Club. 34: 61-84; 387-416.
35: 361-365; 543-554.

REPORT OF THE LIBRARIAN OF THE MICHIGAN ACADEMY OF SCIENCE FOR 1911-1912.

ALEXANDER G. RUTHVEN.[1]

The work of the librarian during the fiscal year was mostly restricted to the routine duties of the position. The card index of members was revised, the annual report sent out to members and exchanges, and the incomplete sets of various members and exchanges filled out. The librarian received from the secretary 197 copies of past reports stored at the Michigan Agricultural College, which materially adds to the reserve stock of each report. We now have all of the reserve copies at Ann Arbor, and a card catalog of all of the persons who have ever been members of the Academy, with the number of reports which they have received.

Ten institutions have been dropped from the exchange list and ten added during the year so that there are now 568 institutions on the list. The revised list of exchanges follows:

LIST OF EXCHANGES.*

Aberdeen Natural History Society, Aberdeen, Scotland.
Aberdeen University Library, Aberdeen, Scotland.
Academia de Ciencias, Mexico City, Mexico.
Academia de Ciencias, Médicasy Fisicas, Havana, Cuba.
Academia de Ciencias Naturales, Lima, Peru.
Academia Nacional de Ciencias, Cordoba, South America.
Academia Polytechnica, Oporto, Portugal.
Academia Real das Sciences, Lisbon, Portugal.
Académie de Metz, Metz, Lorraine, Germany.
Académie des Belles-Lettres, Sciences, La Rochelle, France.
Académie des Sciences, Art et Belles-Lettres, Dijon, France.
Académie des Sciences, Belles-Lettres, Lyon, France.
Académie des Sciences, Belles-Lettres et Arts, Rouen, France.
Académie des Sciences et Letters, Montpellier, France.
Académie des Sciences Inscriptions et Belles-Lettres, Toulouse, France.
Académie Nationale des Sciences, Caen, France.
Academy of Science, New Orleans, Louisiana.
Academy of Natural Sciences, Philadelphia, Pennsylvania.
Academy of Natural Sciences, St. Paul, Minn.
Accademia delles Scienze dell' Istituto, Bologna, Italy.
Accademia delle Scienze, Lettere ed Arti, Genoa, Italy.
Adrian Scientific Society, Adrian, Michigan.

[1]Address: Care of University of Michigan Museum, Ann Arbor, Michigan, U. S. A.
*Address all exchanges "care of the Library of the University of Michigan, Ann Arbor, Michigan, U. S. A."

Aix University Library, Aix-en-Provence, Bouches du Rhone, France.
Akademija Umiejetnosci, Krakau, Austria- Hungary.
Alabama Geological Survey, University, Alabama.
Albion College, Library, Albion, Michigan.
Alma College, Library, Alma, Michigan.
Alpena Public Library, Alpena, Michigan.
American Academy of Arts and Sciences, Boston, Massachusetts.
American Academy of Medicine, Easton, Pennsylvania.
American Association for the Advancement of Science, Washington, D. C.
American Entomological Society, Philadelphia, Pennsylvania.
American Geographical Society, New York City, New York.
American Geologist, Minneapolis, Minnesota.
American Gynecological Society, New York City, New York.
American Laryngological Association, New York City, New York.
American Midland Naturalist, Notre Dame, Indiana.
American Museum of Natural History, New York City, New York.
American Philosophical Society, Philadelphia, Pennsylvania.
Archives des Sciences Physiques et Naturelles, Geneva, Switzerland.
Asiatic Society of Bengal, Calcutta, India.
Astronomical Society of the Pacific, San Francisco, California.
American School of Classical Studies, Athens, Greece.
Atlanta University, Library, Atlanta, Georgia.
Bayerische Botanische Gesellschaft, Munich Germany.
Baylor University, Library, Waco, Texas.
Beloit College, Library, Beloit, Wisconsin.
Berliner Entomologischer Verein, Berlin, Germany.
Besancon University, Library, Besancon, France.
Bibliotheca Nacional, Buenos Aires, Argentine Republic.
Bibliotheca da Faculdade de Direito da Universidade, Pernambuco, Brazil.
Bibliotheque Nationale Paris, France.
Bibliotheca Nacional, Rio de Janeiro, Brazil.
Biblioteca Nazionale Centrale, Florence, Italy.
Biologiska Foerening, Stockholm, Sweden.
Birmingham School Board, Birmingham, England.
Bodleian Library, University of Oxford, Oxford, England.
Boston Medical Library, Boston, Massachusetts.
Boston Public Library, Boston, Massachusetts.
Boston Scientific Society, Boston, Massachusetts.
Boston Society of Natural History, Boston, Massachusetts.
Botanischer Verein, Freiburg-im-Breisgau, Germany.
Botanischer Verein, Koenigsberg, Prussia, Germany.
Botanischer Verein, Landshut, Germany.
Botanischer Verein Provinz Bradenburg, Berlin, Germany.
Bowdoin College, Library, Brunswick, Maine.
Bradford Scientific Association, Bradford, England.
Bristol Naturalists' Society, Bristol, England.
British Association for the Advancement of Science, London, England.
British Museum, London, England.
Brooklyn Institute of Arts and Sciences, Brooklyn, New York.

Brown University, Library, Providence, Rhode Island.
Bryn Mawr College, Library, Bryn Mawr, Pennsylvania.
The Bryologist, Brooklyn, New York.
Buffalo Society of Natural Sciences, Buffalo, New York.
Calcutta University, Library, Calcutta, India.
California Academy of Science, San Francisco, California.
California University, Library, Berkeley, California.
Calumet Public Library, Calumet, Michigan.
Cambridge Philosophical Society, Cambridge, England.
Cambridge University, Library, Cambridge, England.
Canadian Institute, Toronto, Canada.
Catholic University, Library, Washington, D. C.
Central State Normal School, Library, Mt. Pleasant, Michigan.
Charleston Museum, Charleston, South Carolina.
Chicago Academy of Science, Lincoln Park, Chicago, Illinois.
Chicago University, Library, Chicago, Illinois.
Cincinnati Society of Natural History, Cincinnati, Ohio.
Cincinnati University, Library, Cincinnati, Ohio.
City of Londan Entomological and Natural History Society, London, England.
College of Physicians, Philadelphia, Pennsylvania.
Colorado College, Library, Colorado Springs, Colorado.
Colorado School of Mines, Library, Golden, Colorado.
Colorado Scientific Society, Denver, Colorado.
Colorado University, Library, Boulder, Colorado.
Columbia University, Library, New York City, New York.
Commerz-Biblothek, Hamburg, Germany.
Commissao Geographic e Geologica, San Paulo, Brazil.
Concilium Bibliographicum, Zurich, Switzerland.
Connecticut Academy of Arts and Sciences, Yale Station, New Haven, Connecticut.
Connecticut State Library, Hartford, Connecticut.
Commissionen for Ledelsen of Geolosiska og Geographiska, Copenhagen, Denmark.
Cornell University, Library, Ithaca, New York.
Dalhousie College, Library, Halifax, Nova Scotia, Canada.
Davenport Academy of Natural Sciences, Davenport, Iowa.
Delaware County Institute of Science, Media, Pennsylvania.
Denison University, Scientific Laboratories, Granville, Ohio.
Denver University, Library, Denver, Colorado.
Department of Mines and Agriculture, Sidney, New South Wales.
Department of the Interior, Canadian Archives, Ottawa, Canada.
Detroit Public Library, Detroit, Michigan.
Deutsche Botanische Gesellschaft, Berlin, Germany.
Deutsche Entomologische National Museum, Berlin, Germany.
Deutsche Geologische Gesellschaft, Berlin, Germany.
Deutscher u. Oesterreichischer Alpen-Verein, Munich, Germany.
Deutscher Wissenschaftlicher Verein, Santiago, Chili.
Division of Entomology, Dominion Department of Agriculture, Ottawa, Canada.
Ecole Normale Supérieure, Paris, France.

Ecole Pratique des Hautes Etudes, Sorbonne, Paris, France.
Edinburgh Field Naturalists and Microscopical Society, Edinburgh, Scotland.
Edinburgh Geological Society, Edinburgh, Scotland.
Edinburgh University, Library, Edinburgh, Scotland.
Elgin Scientific Society, Elgin, Illinois.
Elisha Mitchell Scientific Society, Chapel Hill, North Carolina.
Elphinstone College, Library, Bombay, India.
Entomological Society, Cavendish Square, W. London, England.
Entomological Society of Canada, Quebec, Canada.
Entomological Society of Ontario, Guelph, Canada.
Entomologischer Verein, Stettin, Germany.
Entomologiska Foerening, Stockholm, Sweden.
Essex Institute, Salem, Mass.
Field Museum of Natural History, Chicago, Illinois.
Finska Vetenskap Societet, Helsingfors, Finland.
Folia Bibliographica, Berlin, Germany.
Franklin & Marshall College, Library, Lansaster, Pennsylvania.
Geographical Society of Australia, Queensland Branch, Brisbane, Australia.
Geographical Society of California, San Francisco, California.
Geographical Society of Finland, Helsingfors, Finland.
Geographical Society of Philadelphia, Philadelphia, Pennsylvania.
Geographical Society of Quebec, Quebec, Canada.
Geographische Gesellschaft, Bremen, Germany.
Geographische Gesellschaft, Greifswald, Germany.
Geographische Gesellschaft fuer Thueringen, Jena, Germany.
Geological Society of South Africa, Johannisburg, South Africa.
Geological Survey, Department of Mines and Agriculture, Sidney, New South Wales.
Geological Survey of Missouri, Jefferson City, Missouri.
Geological Survey of Newfoundland, St. Johns, Newfoundland.
Geological Survey of New Jersey, New Brunswick, New Jersey.
Geological Survey of New Zealand, Wellington, New Zealand.
Geological Survey of Victoria, Melbourne, Victoria, Australia.
Geologische Gesellschaft fuer Ungarn, Budapest, Hungary.
Geologiska Commissionen i Finland, Helsingfors, Finland.
Georg-Augusts Universitaet, Goettingen, Germany.
Georgia University, Library, Athens, Georgia.
Glasgow Geological Society, Glasgow, Scotland.
Glasgow School Board, Glasgow, Scotland.
Glasgow University, Library, Glasgow, Scotland.
Government Botanist, Melbourne, Victoria, Australia.
Government Fisheries Station, Tuticorin, India.
Grand Rapids Public Library, Grand Rapids, Michigan.
Grossherz Bad. Albert-Ludwigs Universitaet, Bibliothek, Freiburg, Germany.
Grossherz Hessische Ludwig-Universitaet, Bibliothek, Giessen, Hessen, Germany.
Grossherz Ruprecht-Karls Universitaet, Heidelberg, Germany.
Grossherz Saechsische Gesant Universitaet, Bibliothek, Jena, Germany.

Gulf Biological Station, Baton Rouge, Louisiana.
Hackley Public Library, Muskegon, Michigan.
Hall Fowler Memorial Library, Ionia, Michigan.
Harvard Museum of Comparative Zoology, Cambridge, Massachusetts.
Harvard University, Gray Herbarium, Cambridge, Massachusetts.
Havana University, Library, Havana, Cuba.
Hillsdale College, Library, Hillsdale, Michigan.
Hrvatsko Prirodoslovno Drustvo, Agram, Croatia, Austria-Hurgary.
Hull Literary and Philosophical Society, Hull, England.
Idaho University, Library, Moscow, Idaho.
Illinois Geological Survey, Urbana, Illinois.
Illinois State Laboratory of Natural History, Urbana, Illinois.
Illinois State Museum of Natural History, Springfield, Illinois.
Illinois University, Library, University Station, Urbana, Illinois.
Imperial Charkovskii Universitet, Bibliothek, Charkow, Russia.
Imperial Varsavskij Universitet, Bibliothek, Warsaw, Russia.
Imperial Institute of the United Kingdom, London, England.
Imperial Iurjevskij Universitet, Bibliothek, Dorpat, Russia.
Imperial Moskovskij Universitet, Moskow, Russia.
Imperial Moskofskoie Obshchestvo Iestestvo-Ispytatelei. Moskow, Russia.
Imperial Sankt-Petersburgskoie Mineralogicheskoie Obshchestvo, St. Petersburg, Russia.
Imperial University of Tokyo, Library, Tokyo, Japan.
Indiana Academy of Science, Indianapolis, Indiana.
Indiana Geological Survey, Indianapolis, Indiana.
Indiana University, Library, Bloomington, Indiana.
Inspectorate General of Customs, Statistical Department. Shanghai, China.
Institute de France, Paris, France.
Institute des Mines, St. Petersburg, Russia.
Institute Luxembourgeois, Section des Sciences Naturelles, Luxemburg, France.
Institute of Jamaica, Kingston, Jamaica.
Istituto Historico, Geographico y Ethynographico, Rio de Janeiro, Brazil.
Institution of Civil Engineers, Great George St., London, England.
Iowa Academy of Sciences, Des Moines, Iowa.
Iowa Geological Survey, Des Moines, Iowa.
Iowa University, Library, Iowa City, Iowa.
Iron Mountain Carnegie Library, Iron Mountain, Michigan.
Istituto Geografico Militare, Florence Italy.
Istituto Scientifico della R. Universita, Rome, Italy.
Jackson Public Library, Jackson, Michigan.
Jagellonische Universitaet, Bibliothek, Karkau, Austria-Hungary.
Jardin Botanique de L'Etat, Bruxelles, Belgium.
Jenaische Zeitschrift fuer Medicin u. Naturwissenschaften, Jena, Germany.
John Crerar Library, Chicago, Illinois.
Johns Hopkins University, Baltimore, Maryland.
K. Bayerische Botanische Gesellschaft, Regensberg, Germany.

K. Boehmische Gesellschaft der Wissenschaft, Prag, Austria-Hungary.

K. K. Deutsche Karl-Ferdinand Universitaet, Bibliothek, Prag, Austria-Hungary.

K. K. Geographische Gesellschaft, Wien, Austria-Hungary.

K. K. Geologische Reichsanstalt, Wien, Austria-Hungaria.

K. Leopoldinisch-Carolouinische Deutsche Akademie der Naturforschen, Halle-an-der-Saale, Germany.

K. K. Leopold-Franzens Universitaet, Bibliothek, Innsbruck, Tyroll Austria.

K. Magyar Természettudományi Társulat, Tarsulat, Austria-Hungary.

K. K. Universitaet, Bibliothek, Wien, Austria-Hungary.

K. K. Zoologische-Botanische Gesellschaft, Wien, Austria-Hungary.

K. Zoologische Genootshap "Natura Artis Magistra," Amsterdam, Netherlands.

Kais Universitaet Bibliothek, Kansan, Russia.

Kaiser-Wilhelms-Universitaet, Bibliothek, Strassburg, Germany.

Kaiserliche Universitaet, Bibliothek, St. Petersburg, Russia.

Kansas Academy of Science, Topeaka, Kansas.

Kansas State Historical Society and Department of Archives, Topeka, Kansas.

Kansas University, Lawrence, Kansas.

Kantonale Universitaet, Bibliothek, Bern, Switzerland.

Kentucky State College, Agricultural Experiment Station, Lexington, Ky.

Kjbenhavns Universitet, Bibliothek, Kokenhagen, Denmark.

Kjbenhavns Universitet, Bibliothek, Kopenhagen, Denmark.

Kongl. Albertus Universitaet, Bibliothek, Koenigsberg, Prussia, Germany.

Kongl. Alexanders Universiteiet I Finland, Bibliothek, Helsingfors, Finland.

Kongl. Bayerischen Ludwig-Max.-Universitaet, Munich, Germany.

Kongl. Christian-Albrechts Universitaet, Kiel, Germany.

Kongl. Eberhard-Karls-Universitaet, Bibliothek, Tuebingen, Germany.

Kongl. Frederiks Universitet, Bibliothek, Christiana, Norway.

Kongl. Friedrich-Alexanders Universitaet, Bibliothek, Erlangen, Bayern, Germany.

Kongl. Friedrich-Wilhelms Universitaet, Bilbiothek, Berlin, Germany.

Kongl. Julius-Maximilians Universitaet, Bibliothek, Wurzburg, Germany.

Kongl. Karolinska Universitetet, Bibliotheket, Lund, Sweden.

Kongl. Ungarische Universitaet, Bibliothek, Budapest, Hungary.

Kongl. Universitaet, Bibliothek, Breslau, Germany.

Kongl. Universitaet, Bibliothek, Greifswald, Germany.

Kongl. Universitaet, Muenster in Westfalen, Preussen, Germany.

Kongl. Universitetet I Upsala, Bibliothek, Upsala, Sweden.

Kongl. Zoologisches Institut, Friedrich-Wilhelms Universitaet, Berlin, Germany.

Kongliga Svenska Vetenskap Akademien, Stockholm, Sweden.

Laval University, Library, Quebec, Canada.

Leeds University, Library, Leeds, England.

Leland Stanford University, Library, Stanford University, California.

Linnean Scientific and historical Society, Lancaster, Pennsylvania.
Linnean Society of London, Burlington House, W. London, England.
Linnean Society of New South Wales, Sydney, New South Wales.
Linnean Society of New York, New York City, New York.
Liverpool Geological Society, Liverpool, England.
Liverpool University Library, Liverpool, England.
Lloyd Library, Cincinnati, Ohio.
London School Board, London, England.
McGill University, Library, Montreal, Canada.
Magyar Ornithologiai Koezpont, Budapest, Austria-Hungary.
K. Magyar Természettudományi Társulat, Budapest, Austria-Hungary.
Maine University, Library, Orono, Maine.
Manchester Geographical Society, Manchester, England.
Manchester Geological Society, Manchester, England.
Manchester University, Library, Manchester, England.
Manila University, Library, Manila, Philippine Islands.
Manitoba Historical and Scientific Society, Winnipeg, Manitoba, Canada.
Manitoba University, Library, Winnipeg, Manitoba, Canada.
Marine Biological Laboratory, Wood's Holl, Massachusetts.
Maryland Geological Survey, Baltimore, Maryland.
Massachusetts Board of Cattle Commissioners, Boston, Massachusetts.
Massachusetts Horticultural Society, Boston, Massachusetts.
Medicinische Naturwissenschaftliche Section des Siebenbuergischen Museum Verein, Klausenburg, Austria-Hungary.
Melbourne University, Library, Melbourne, Australia.
Michigan Agricultural College, Library, Agricultural College, Michigan.
Michigan College of Mines, Library, Houghton, Michigan.
Michigan Geological and Biological Survey, Lansing, Michigan.
Michigan State Normal School, Library, Marquette, Michigan.
Michigan State Normal School, Library, Ypsilanti, Michigan.
Milwaukee Public Museum, Milwaukee, Wisconsin.
Minister of Public Instruction, Paris, France.
Minnesota Academy of Natural Science, Minneapolis, Minnesota.
Minnesota University, Library, Minneapolis, Minnesota.
Missouri Botanical Garden, St. Louis, Missouri.
Missouri Bureau of Geology and Mines, Rolla, Missouri.
Missouri University, Library, Columbia, Missouri.
Montana University, Library, Missoula, Montana.
Museo Civico di Storia Naturale; Trieste, Austria-Hungary.
Museo, Nacional, Montevideo, Uruguay.
Mureo Nacional de Buenos Aires, Buenos Aires, South America.
Mueso Nacional de Historia Natural, Mexico City, Mexico.
Museu Paraense de Historia Natural, Para, Brazil.
Museu Paulista, San Paulo, Brazil.
Museum fuer Naturn. Heimatkunde, Magdeburg, Germany.
Museum of Geology and Archaeology, Princeton, New Jersey.
Museum of Natural History, Springfield, Massachusetts.
National Academy of Sciences, Washington, D. C.

National University, Library, Athens, Greece.
Natural History and Philosophical Society, Belfast, Ireland.
Natural History Society, Montreal, Canada.
Natural History Society of Glasgow, Glasgow, Scotland.
Natural History Society of New Brunswick, St. Johns, New Brunswick.
Natural History Society of Northumberland, Newcastle-upon-Tyne, England.
Naturforschende Gesellschaft, Bamburg, Germany.
Naturforschende Gesellschaft, Basel, Switzerland.
Naturforschende Gesellschaft, Bern, Switzerland.
Naturforschende Gessellschaft, Gorlitz, Germany.
Naturforschende Gesellschaft, Leipzig, Germany.
Naturforschende Gesellschaft in Luzern, Switzerland.
Naturforschende Gesellschaft, Zuerich, Switzerland.
Naturforschender Verein, Bruenn, Austria-Hungary.
Naturhistorische Gesellschaft, Hanover, Prussia, Germany.
Naturhistorische Gesellschaft, Nurnburg, Bavaria, Germany.
Naturwissenschaftliche Gesellschaft, Chemnitz, Saxony, Germany.
Naturwissenschaftliche Gesellschaft, St. Gall, Switzerland.
Naturwissenschaftlicher Verein, Bremen, Germany.
Naturwissenschaftlicher Verein, Frankfurt-an-der-Oder, Prussia, Germany.
Naturwissenschaftlicher Verein, Hamburg, Germany.
Naturwissenschaftlicher Verein, Karlsruhe, Germany.
Naturwissenschaftlicher Verein, Lueneburg, Prussia, Germany.
Naturwissenschaftlicher Verein, Magdeburg, Saxony, Germany.
Naturwissenschaftlicher Verein, Osnarbrueck, Prussia, Germany.
Naturwissenschaftlicher Verein, Regensburg, Bavaria, Germany.
Naturwissenschaftlicher Verein fuer Saechsen u. Thueringen, Halle-an-der-Saale, Prussia, Germany.
Naturwissenschaftlicher Verein fuer Schleswig-Holstein, Kiel, Prussia, Germany.
Naturwissenschaftlicher Verein fuer Schwaben u. Neuburg, Augsburg, Germany.
Naturwissenschaftlicher Verein fuer Steirermark, Graz, Austria.
Nebraska University, Library,. Lincoln, Nebraska.
Nederlandsche Entomologische Vereeniging, Leiden, Holland.
Nevada University, Library, Reno, Nevada.
New York Academy of Medicine, New York City, New York.
New York Botanical Gardens, Bronx Park, New York City, New York.
New York Public Library, New York City, New York.
New York State Library, Albany, New York.
New York State Museum of Natural History, Albany, New York.
Norges Geologiske Undersoegelse, Christiania, Norway.
Northhampton Institute, St. Johns Street Road, London, England.
North Carolina Geological Survey, Raleigh, North Carolina.
North Carolina University Library, Chapel Hill, North Carolina.
North Dakota Experiment Station, Agricultural College, Fargo, North Dakota.
North Dakota University, Library, Grand Forks, North Dakota.

Northwestern University, Library, Evanston, Illinois.
Nova Scotian Institute of Science, Halifax, Nova Scotia, Canada.
Oahu College, Honolulu, Hawaii.
Oberhessiche Gesellschaft fuer Natur-u. Heilkunde, Giessen, Hesse, Germany.
Oberlin College, Library, Oberlin, Ohio.
Observatorio do Rio de Janeiro, Rio de Janeiro, Brazil.
Oesterreichischer Reichs-Forst Verein, Wien, Austria-Hungary.
Ohio Mechanics Institute, Cincinnati, Ohio.
Ohio State Academy of Science, Page Hall, Ohio State University, Columbus, Ohio.
Ohio State Archaeological and Historical Society, Columbus, Ohio.
Ohio State University, Library, Columbus, Ohio.
Ohio Wessleyan University, Library, Delaware, Ohio.
Oklahoma University, Library, Norman, Oklahoma.
Olivet College, Library, Olivet, Michigan.
Onondaga Academy of Science, Syracuse, New York.
Ontaria Minister of Education, Ottawa, Canada.
Oregon University, Library, Eugene, Oregon.
Orto Botanico, Palermo, Italy.
Oschshestvo Iestestvo-Ispytalelei pri Imper, Kazanskom Universitetie, Kazan, Russia.
Oxford University Entomological Society, Oxford, England.
Peabody Academy of Science, Salem, Massachusetts.
Peabody Institute, Library, Baltimore, Maryland.
Peabody Museum of American Archaeology and Ethnology, Cambridge, Massachusetts.
Pennsylvania University, Library, Philadelphia, Pennsylvania.
Perthshire Society of Natural Science, Perth, Scotland.
Petermann, Dr. A., Geographischer Mitteilungen, Gotha, Germany.
Petoskey Public Library, Petoskey, Michigan.
Phillips Academy, Department of Archaeology, Andover, Massachusetts.
Philosophical Society of Glasgow, Glasgow, Scotland.
Popular Science Monthly, Sub-station 84, New York City, New York.
Portland Society of Natural History, Portland, Maine.
Princeton Academy of Science, Princeton, Illinois.
Princeton University, Library, Princeton, New Jersey.
Provinzial-Verein fuer Wissenschaft-u. Kunst, Muenster, Prussia, Germany.
Public Gardens and Plantations, Gordon Town, Jamaica.
Public Library, Bay City, Michigan.
Public Library, Traverse City, Michigan.
Public Library and Museum, Brighton, England.
Public School, Library, Adrian, Michigan.
Purdue University, Library, Lafayette, Indiana.
Queen's College, Library, Belfast, Ireland.
Queen's College, Library, Galway, Ireland.
Queen's University, Library, Kingston, Canada.
Real Academica de Ciencias Exactes, Fisicas y Natureals, Madrid, Spain.

Real Academia de Ciencias y Artes, Barcelona, Spain.
R. Accademia delle Scienze e Belle Lettere, Naples, Italy.
R. Accademia di Scienze, Lettere ed Art, Padua, Italy.
R. Accademia di Scienze, Lettere Belle-Arti, Palermo, Italy.
Regia Superiore d' Agricoltura Biblioteca, Portici, Italy.
Regia Università degli Studi, Biblioteca, Bologna, Italy.
Regia Università degli Studi, Genoa, Italy.
Regia Università degli Naples, Biblioteca, Naples, Italy.
Regia Università degli Studi, Biblioteca, Padua, Italy.
Regia Università degli Studi, Biblioteca, Palermo, Italy.
Regia Università degli Studi, Biblioteca, Parma, Italy.
Regia Università degli Studi, Biblioteca, Pavia, Italy.
Regia Università degli Studi, Biblioteca, Pisa, Italy.
Regia Università degli Studi, Biblioteca, Rome, Italy.
Regia Università degli Studi, Biblioteca, Turbin, Italy.
Regio Istituto Veneto di Scienze, Venice, Italy.
Rheinische Friedrich-Wilhelms Universitaet, Bibliothhek, Bonn, Germany.
Rijks Herbarium, Leidan, Holland.
Rijks Universiteit, Bibliothek, Groningen, Holland.
Kijks Universiteit, Bibliothek, Leiden, Holland.
Rijks Universiteit, Bibliothek, Utrecht, Holland.
Rivista Argentina, La Plata, South America.
Rivista Italiana di Scienze Naturali, Siena, Italy.
Rochester Academy of Science, Rochester, New York.
Royal Astronomical Society of Canada, Toronto, Canada.
Royal Botanic Garden, Edinburgh, Scotland.
Royal Botanic Garden, Kew, England.
Royal Botanic Garden, Sibpur, Near Calcutta, India.
Royal Botanic Society, Inner Circle, Regents Park, London, England.
Royal Dublin Society, Dublin, Ireland.
Royal Geographical Society, London, England.
Royal Geographical Society of Australia, Adelaide, South Australia.
Royal Geological Society of Cornwall, Penzance, England.
Royal Irish Academy, Dublic, Ireland.
Royal Istituto Botanico, Palermo, Italy.
Royal London Ophthalmic Hospital, City Road, E. C. London, England.
Royal Medical and Chirurgical Society, London, England.
Royal Microscopical Society, Kings College, W. C. London, England.
Royal Society of Arts, John St., Adelphia, London, England.
Royal Society of Canada, Ottawa, Canada.
Royal Society of Edinburgh, Edinburgh, Scotland.
Royal Society of New South Wales, Sydney, New South Wales.
Royal Society of Queensland, Brisbane, Queensland, Australia.
Royal Society of South Australia, Adelaide, South Australia.
Royal Society of Tasmania, Hobarton, Tasmania, Australia.
Royal Society of Victoria, Melbourne, New South Wales.
Saellskepet pro Fauna et Flora Fennica, Helsingfors, Finland.
Sage Library, Bay City, Michigan.
Saginaw East Side Public Library, Saginaw, Michigan.

St. Andrews University, Library, St. Andrews, Scotland.
St. Francis Xavier's College, Antigonish, Nova Scotia, Canada.
St. Louis Academy of Science, St. Louis, Missouri.
San Diego Society of Natural History, San Diego, California.
School of Mines, Ballerat, Victoria, Australia.
Schweizer Entomologischen Gesellschaft, Bern, Switzerland.
Schweizerischer Forst-Veren, Zurich, Switzerland.
Scottish Natural History Society, Edinburgh, Scotland.
Seattle Public Library, Seattle, Washington.
Sheffield University, Library, Sheffield, England.
Smith College, Library, Northhampton, Massachusetts.
Smithsonian Institution, Washington, D. C.
Smithsonian Institution, Bureau of International Catalogue of Scientific Literature, Washington, D. C.
Sociedad Agricola Mexicana, Mexico City, Mexico.
Sociedad Cientifica "Antonio Alzate," Mexico City, Mexico.
Sociedad Cientifica Argentina, Buenos Aires, Argentine Republic.
Sociedad de Ciencias Fisicas y Naturales, Caracas, Venezuela.
Sociedade de Geographica, Rio de Janeiro, Brazil.
Sociedad Scientifica, San Paulo, Brazil.
Società Adriatica di Scienze Naturali, Trieste, Austria-Hungary.
Società Entomological Italiana, Florence, Italy.
Società Italiana delle Scienze, Rome, Italy.
Società Italiana di Scienze Naturali, Milan, Italy.
Società Toscana di Scienze Naturali, Pisa, Italy.
Societas pro Fauna et Flora Fennieca, Helsingfors, Finland.
Société Belge d' Astronomie, Bruxelles, Belgium.
Société Belge de Géographie, Bruxelles, Belgium.
Société Belge de Geologie, Bruxelles, Belgium.
Société de Bilogique, Paris, France.
Société de Botanique du Grand-Duché de Luxembourg, Luxemburg, France.
Société de Geographie, Toulouse, France.
Société des Naturalistes de Bessarbie, Kisheinew, Russia.
Société des Sciences, Agriculture et Arts de la Basse-Alsace, Strassburg, Germany.
Société de Sciences de Nancy, Nancy, France.
Société des Sciences Historiques et Naturelles de la Corse, Bastia, France.
Société des Sciences Historiques et Naturelles de l'Yonne, Auxerre, France.
Société des Sciences Naturelles, Neuchatel, Switzerland.
Société des Sciences Naturelles, Versailles, France.
Société des Sciences Physiques et Naturelles, Zurich, Switzerland.
Société Entomologique de Belgique, Bruxelles, Belgium.
Société Entomologique de France, Paris, France.
Société Géologique de Belgique, Liege, Belgium.
Société Géologique de France, Paris, France.
Société d'Historie Naturelle, Autun, France.
Société d'Horticulture et de Botanique, Havre, France.
Société d'Horticulture et de Botanique, Marseilles, France.

Société Linnéenne de Bordeaux, Bordeaux, France.
Société Linnéenne de Lyon, Lyon, France.
Société Linnéenne de Normandie, Caen, France.
Société Linnéenne du Nord de la France, Amiens, France.
Société Nationale des Sciences Naturelles, Cherbourg, France.
Société Royale de Botanique de Belgique, Bruxelles, Belgium.
Société Royale des Sciences, Liege, Belgium.
Société Royale Linnéenne de Bruxelles, Bruxelles, Belgium.
Société Scientifique de Bruxelles, Bruxelles, Belgium.
Société Scientifique de Chevtshénko, Lemberg, Austria-Hungary.
Société Zoologique de France, Paris, France.
Society for the Development of Experimental Science, Moscow, Russia.
South African Journal of Science, Cape Town, South Africa.
South Dakota Geological Survey, Vermillion, South Dakota.
State Board of Forestry, Indianapolis, Ind.
State Historical Society of South Dakota, Pierre, South Dakota.
Staten Island Association of Arts and Sciences, New Brighton, New York.
Sydney University Library, Sydney, New South Wales.
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Ufficio Centrale Meteorologico e Geodinamico, Rome, Italy.
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Washington University, Library, Seattle, Washington.
Washington University, Library, St. Louis, Missouri.
Western Reserve University, Library, Cleveland, Ohio.
Western State Normal School, Library, Kalamazoo, Michigan.
Wisconsin Academy of Science, Madison, Wisconsin.
Worcester Natural History Society, Worcester, Massachussets.
Yale University, Forestry School, New Haven, Connecticut.
Yale University, Library, New Haven, Connecticut.
Yale University, Observatory, New Haven, Connecticut.
Yorkshire Geological and Polytechnical Society, Halifax, England.
Zeitschrift fur wissenschaftliche Insectenbiologie, Berlin, Germany.
Zentral-Bibliothek, Munich, Germany.
Zoological Society, Fairmount Park, Philadelphia, Pennsylvania.
Zoologischer Anzeiger, Leipzig, Germany.
Zurich University, Library, Zurich, Switzerland.

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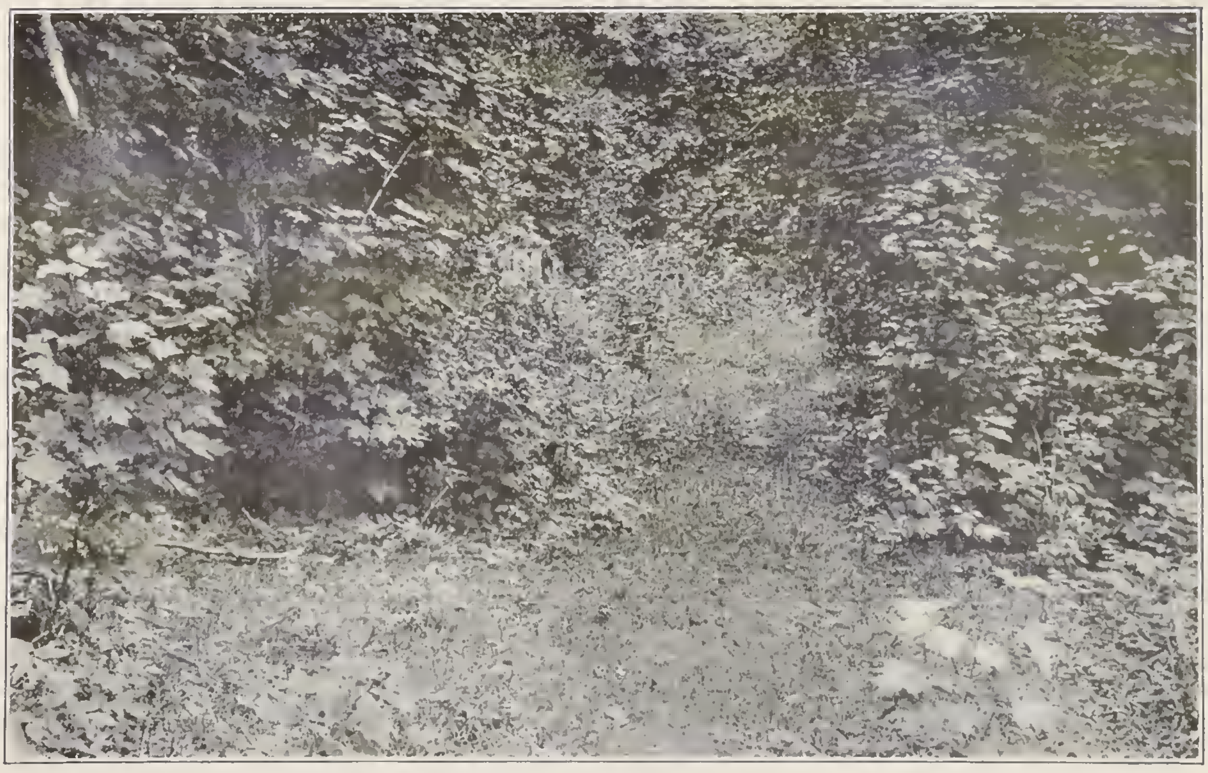

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Fig. 2.—Light House Point, Charity Island, looking toward the island.

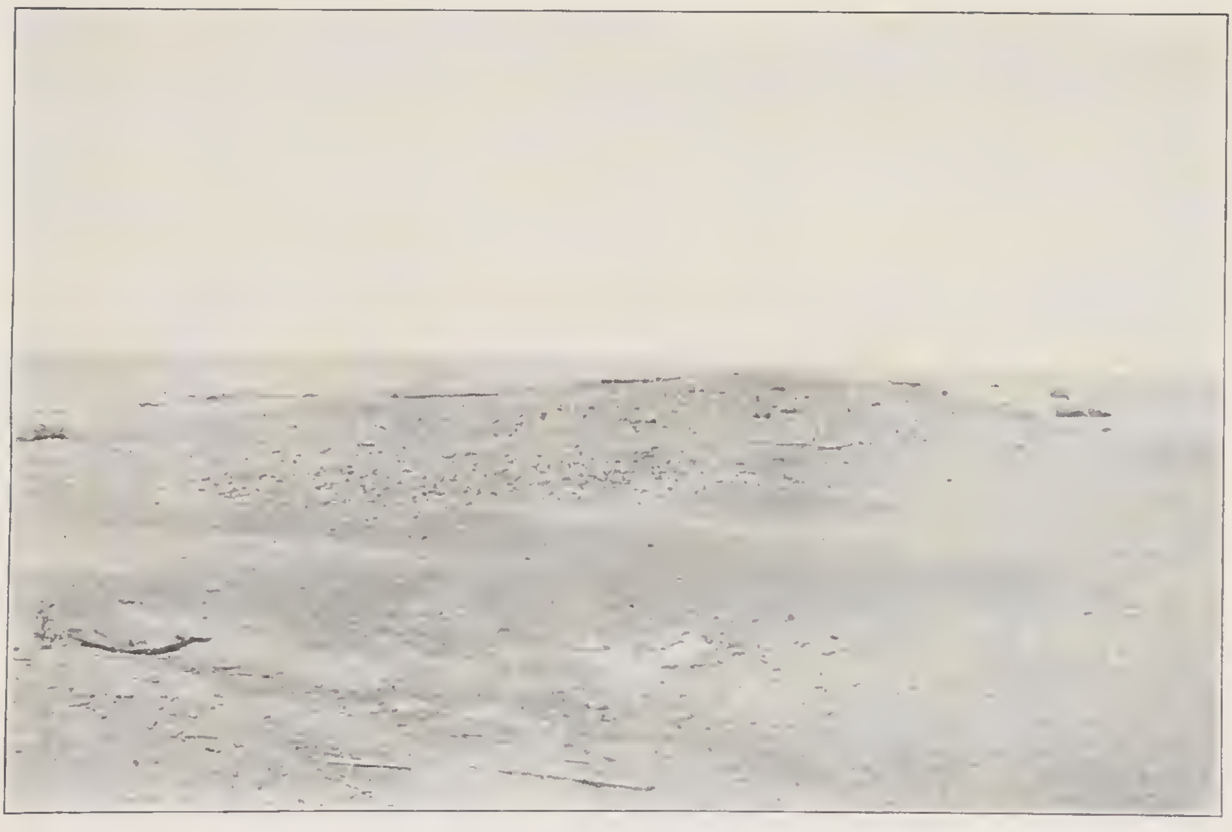

Fig. 3.—Light House Point, Charity Island, looking toward the end of the point.

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Fig. 19.—Dead adult, young, eggs, and nests of Common Tern, Gull Rock.

FIG. 20.—General view of Little Charity Island.

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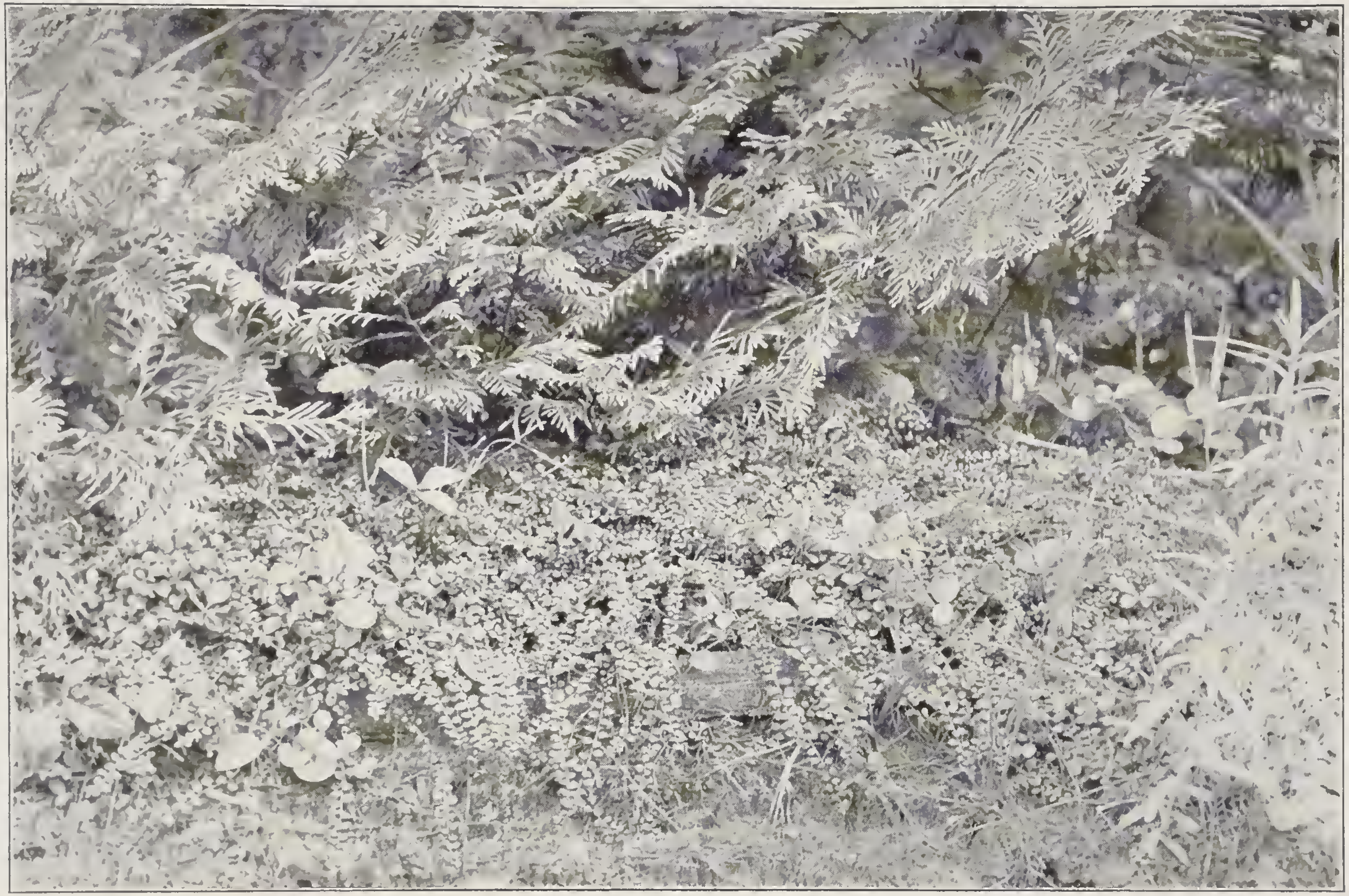

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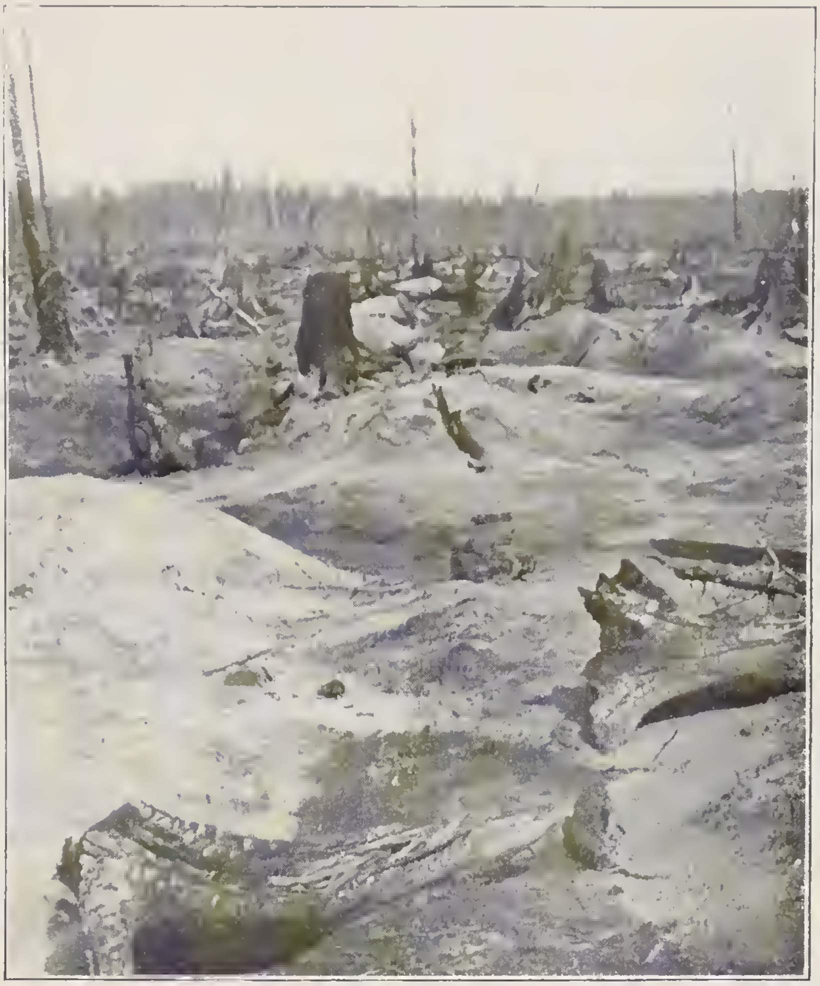

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